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IMPROVING THE PROGRAMING OF COMPLEX PICTORIAL MATERIALS--DISCRIMINATION LEARNING AS AFFECTED BY PRIOR EXPOSURE TO AND RELEVANCE OF COMPONENTS OF THE FIGURAL DISCRIMINANDA.

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THIS STUDY INVOLVED THE IDENTIFICATION OF (1) RELATIONSHIPS BETWEEN REINFORCEMENT AND PHYSICAL COMPONENTS OF COMPLEX PICTORIAL STIMULI IN DISCRIMINATION LEARNING AND (2) VARIABLES RELATED TO PRIOR EXPERIENCE WITH PICTORIAL STIMULI USED IN DISCRIMINATION LEARNING. LINE SHAPES WERE USED AS STIMULI. THESE SHAPES WERE VARIED BY ADDING SOME LINES THAT ASSOCIATED WITH REINFORCEMENT AND OTHERS THAT DID NOT. PRIOR EXPERIENCE (PRETRAINING) IN THE STUDY WAS PROVIDED BY REPEATED EXPOSURE TO SHAPES THAT WERE EITHER THE SAME AS, SIMILAR TO, OR DIFFERENT FROM THOSE USED IN THE DISCRIMINATION TASKS. SUBJECTS WERE INSTRUCTED TO OBSERVE PRETRAINING SHAPES CAREFULLY BUT WERE NOT GIVEN INDICATIONS OF ANY SUBSEQUENT TASKS. THE PRINCIPLE OF ASSOCIATING REINFORCEMENT WITH DISCRIMINATION LEARNING TASKS TO FACILITATE LEARNING WAS CONFIRMED. NO SIGNIFICANT DIFFERENCES AS A RESULT OF THE VARIOUS PRETRAINING CONDITIONS COULD BE FOUND. (JH)

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CHAPTER I

INTRODUCTION

General Statement of the Problem

Investigation of the variables significantly related to the effective programming of pictorial materials has received relatively little attention from those who have done research in the area of audio-visual education. The poverty of research in this area persists in spite of the increasing awareness of the basic importance of such investigations by those engaged in the construction of programmed pictorial learning materials (Bern, 1960; Schramm, 1960). The programming of motion pictures and still pictorial sequences whether used in conventional or automated instruction places most urgent demands upon this most sparsely studied area. Allen, in commenting upon the "dearth of research on the effectiveness of pictorial illustration," concludes, "It appears that a great deal of study still needs to be made of the factors within pictorial illustration that lead to increased learning" (Allen, 1960, p. 121).

This study is generally concerned with three "factors within pictorial illustration that may lead to increased learning."

1. One of these factors is the number of relevant cues, i.e., cues, the presence or absence of which determine what behavior is appropriate, that is what behavior is reinforced.

2. Another factor is the number of irrelevant cues, i.e., cues, the presence or absence of which do not determine which behavior is reinforced.

3. The third is the factor of prior experience with pictorial stimuli. Recent experimental approaches utilizing methods that allow sampling of complex pictorial variables such as shape are permitting experimental investigation of these questions that have so long avoided controlled study.

Origin of the Problem

The factors related to the discrimination of complex figures have been derived from a consideration of the results of research on related questions. Most of these research results were based upon the use of figural and pictorial stimuli. These research studies came primarily from the fields of audio-visual communication and learning psychology.

Those who have conducted and summarized research in audio-visual communication have stated that there is serious need for research on the pictorial stimuli variables that facilitate learning (Allen, 1960; Hoban, 1960; and Schramm, 1960). This poverty of research on pictorial stimulus materials in the audio-visual field extends to other potentially related fields such as perceptual learning and is illustrated by the repeated statements of difficulties in answering the "question of specification of relevant stimuli dimensions against which to relate discriminability" of complex stimuli (Vanderplas, 1958, p. 383). Only a bare beginning has been made in describing complex stimuli such as pictorial illustrations in such ways that specific factors responsible for transfer can be identified (Arnoult, 1957, p. 379). Until such factors can

be identified, persons having interest in either experimental or applied problems related to pictorial or figural stimuli will find predictions of behavior elicited by such stimuli to be unreliable and of limited usefulness.

Considerable experimental and theoretical work has been done in the area of the discrimination of simple stimuli. Most of the current theories of discrimination learning have assumed a population of stimuli or cues that are sampled from trial to trial. Predictions from these theories have usually been based upon assumptions of psychological equivalence of cues. However, empirical findings "about the nature of the cues, either in terms of their physical properties or their psychological attributes" have not consistently supported the assumption of cue equivalence (Dodwell, 1961, p. 375). Experimental and theoretical consideration of the problem continues (Estes, 1961). Although relatively simple stimuli continue to be difficult to describe in ways that can lead to generalization and prediction, there have been recent efforts to describe more complex stimuli. Attempts to quantitatively describe the physical properties of shapes have been made (Attneave & Arnoult, 1956). A number of studies have described relationships between stimuli so described and transfer situations (Arnoult, 1953; Arnoult, 1956a; Attneave, 1957a; Attneave, 1957b; Kurtz, 1953).

The pictorial stimuli used in traditional audio-visual research have not been described quantitatively. Only the grossest physical properties have been described for experimental control. These properties, such as hue, have often been described only in

dichotomous terms, i.e., the presence or absence of the property. In spite of the difficulty in making quantitative descriptions of pictorial stimuli, many experimental studies have been conducted to learn behavioral correlates of such stimuli. The independent variables in some of these studies concerned the physical properties of pictorial illustration. In other studies, the independent variables concerned variations in prior experience with the same or related stimuli. Studies of these two classes of variables affecting learning to discriminate pictorial stimuli suggested lines of research pursued in the present study.

Relevant Stimulus Components of Pictorial Stimuli. For audio-visual work it has been generally recommended that the use of relatively more realistic or life-like stimulus material would facilitate learning (Finn, 1953; Dale, 1954). Consequently many research studies originated by persons in the audio-visual area have been designed to test the prediction that pictorial stimuli that omitted color, motion, fine detail, etc., would be less effective stimuli for learning tasks than pictorial stimuli that included these properties.

Among the physical properties of pictorial stimuli that have been varied experimentally are color (Hoban, 1960), size (Ash, 1949), figural distortion (Gibson, 1954), motion (Allen, 1960), camera angle (Roshal, 1949), and figural detail (Cobun, 1960). Other studies concerned with these and other physical properties of pictorial stimuli are reviewed in Allen (1960) and Hoban (1950, 1960). In general, findings in these studies have been inconclusive

with respect to the hypothesis of facilitation of learning with more life-like stimuli.

Allen and Hoban suggest that the relative effectiveness of stimulus characteristics may be contingent upon the particular response to be evoked and the relationship of reinforcement to particular stimulus properties. Hoban quotes Neal E. Miller's prediction on color as an example. "Color should be an advantage if it is one of the most relevant cues or can be used to emphasize relevant cues; it should be a disadvantage if it distracts or complicates" (Hoban, 1960, p. 98; Miller, 1957). The investigation of physical properties of pictorial stimuli, in terms of their relevance to a particular learned behavior rather than to learning in general, has only recently been conceptualized by persons doing research in audio-visual communication. Programatic research on the relevance of selected physical properties of pictorial stimuli to specific behavior-to-be-learned has not yet been reported in the audio-visual literature.

Prior Experience With Pictorial Stimuli. As a given response becomes well established to a complex stimulus, wide variations in the physical properties of the stimulus may have little effect upon the probability of evoking that response. Knowlton illustrates this point in connection with a class of stimuli he refers to as signs. "...a sign's independence (re 'meaning'), of physical parameters like stimulus intensity;...concerns the fact that the reaction (overt or covert) to a sign is governed by the learned significance of the sign. It is not governed by the energy strength

or stimulus pattern of the sign" (Knowlton, 1960, p. 22). Pictorial illustrations as used in educational settings commonly include shapes, colors, patterns, etc. that evoke well-established responses such as "tree", "myself", or "ball". These responses may be reliably observed through extreme variations in certain physical dimensions of complex stimuli such as those obtained by substituting a pictorial illustration for the subject of that illustration. In connection with motion picture research, Carpenter observes that, "the effects of film instruction, within certain limits, depend more upon the characteristics of the perceivers, individuals, and audiences, than upon the elemental variables within films themselves" (Allen, 1960).

Among the studies concerned primarily with variations in prior experience associated with pictorial stimuli are those that have varied the number of presentations (Hirsch, 1951; Jaspen, 1950; Kurtz and others, 1950), response mode (Michael, 1951; Harby, 1952; Ash & Carlton, 1951), instructional set (Michael, 1951; Hovland & others, 1949), and learning-to-learn (Commonwealth of Australia, 1950). Allen (1960) presents a more complete summary of related studies. Findings in general have been consistent with predictions based on learning studies in other contexts.

However, a general failure to support hypotheses occurred when response mode was the independent variable. The relatively more covert response was observed to be associated with performance equal to or superior to performance associated with the relatively more overt mode. Harby (1952), Ash & Carlton (1951), and Roshal (1950)

in the earlier audio-visual studies and Cook & Spitler (1960), and Kaess & Zeaman (1960) in recent studies of self-teaching devices have reported relatively more learning associated with the more covert response. Interaction with other factors such as rate of presentation has been proposed to account for the unexpected superiority of the more covert response (Roshal, 1950); however, such an explanation could not account for the results in other studies. The question of which combinations of pictorial stimuli and responses might result in optimal learning has not been answered. The unanswered questions with regard to response mode are not unique. Related work on the programming of verbal materials has resulted in the failure to find general confirmation of other existing predictions of optimal sequences of events for learning (Stolurow, 1961, p. 85). The unconfirmed predictions and related research studies on verbal programming suggest some of the many problems facing the pictorial programmer. Most of these problems are related to the question of determining the kinds of prior experience with a pictorial stimulus that facilitate learning.

Pictorial stimuli, such as those presented by means of educational television, motion pictures, printed and projected illustrations, have been typically presented in contexts where the response of observing the stimuli without any additional overt response is appropriate. There is urgent need to assess the relative merits of the observation response and other responses involving relatively more overt behavior for both theoretical and practical reasons (Stolurow, p. 86). One of the purposes of the present study was to

test the effect upon discrimination learning of pretraining conditions in which the stimuli are presented with instructions to observe carefully without any additional overt response required.

Covariation of Prior Experience and Relevant Stimulus Components of Pictorial Stimulus. The probability that a given complex stimulus will evoke a given response has been described as a function of the quality and number of cues present and the reinforcement history of responses in the presence of those cues (Estes, 1961). The quality and number of cues present has been most often related to the physical dimensions of the stimulus. The reinforcement history is an aspect of prior experience with the stimulus. If either of these parameters that describe response probability is unknown, the probability cannot be predicted. We often deal experimentally with some aspect of the learning situation that we feel is related to one of these parameters while attempting to control the other. In the reported audio-visual experimentation, these two classes of variables have been either difficult or impossible to control independently.

This difficulty is illustrated by attempts to compare pictorial stimuli that vary with respect to abstractness. Abstractness of a given stimulus cannot be defined without reference to some other stimulus object which has become associated with it in the course of prior experience. For example, a photograph of a cow can be described in terms of abstractness with respect to either the cow or to another copy of the same photograph. It may be considered relatively abstract in the former case and not in the latter. In

addition to the learned aspect of abstractness, there is the possible variation in the physical dimensions of the stimuli in question. Once the referent is established, such as a particular live cow, pictorial and other representations can be constructed of it differing in the kinds and number of physical stimulus dimensions present. A variation in the physical dimensions of a complex stimulus may result in an uncontrolled change in the response probabilities due to prior experience with stimulus elements now present (Cobun, 1960).

The value of an experimental design that permits independent variation of relevant elements of multi-dimensional stimuli and prior experience with them, is illustrated by the finding of interaction between such variables in the Cobun study. Stolurow (1961) stresses the value of finding such interactions in order to provide more effective guides for developing effective programmed material. More extensive use of research designs which can reveal interactions seems to be indicated for research with pictorial stimuli.

Related Research in the Psychology of Learning

Most of the audio-visual studies are characterized by the use of highly complex pictorial stimuli. While research on discrimination behavior with visual stimuli has a considerable history in psychology, the trend has been to favor the use of stimuli that can be more readily described in a quantitative way. These visual stimuli are characteristically simple as compared with the complex pictorial stimuli. However, as strategies have developed for describing and controlling dimensions of complex stimuli, there has appeared a growing number of empirical studies and generalizations that suggest fruitful lines of further inquiry.

The development of techniques for describing and systematically varying shape (Attneave & Arnoult, 1956) have given rise to a series of experiements on the differential effect of varying the number of figural elements correlated with a reinforcing event in discrimination learning. Using similar stimulus materials, another group of experiments on the effects of prior experience with part or all of the stimulus array has appeared. Such studies have contributed to the development of the hypotheses of the present study.

Transfer Following Prior Presentation of Pictorial Stimuli. One group of transfer of learning studies involves prior exposure of the subject to the same or similar stimuli as those presented in the transfer task, while varying the response in the pretraining and transfer task. Some of these studies have presented the stimuli in pretraining with instructions for S to observe or draw a figure representing the common components of a stimulus array. In both cases pretraining responses to the stimuli to be used in the transfer task were not differentially reinforced by E. Non-differentially reinforced prior exposure of stimuli that are later used in transfer has been found not to facilitate learning when compared with a condition of observing stimuli drawn from a control population of relatively unrelated stimuli (Cantor, 1955; Goss & Greenfield, 1958). Arnoult (1956b) reports facilitation of recognition response following such pretraining when compared with chance performance. He did not include a control condition with presentation of unrelated figures. Pfafflin (1960) reports results indicating that pretraining by presenting stimuli with instructions to observe, facilitates

discrimination learning of shapes when compared with no pretraining and particularly when the stimulus figures were comparatively more meaningful as indicated by a measure of reliability of verbal associations to the figures. The control of pretraining on relatively unrelated stimuli was not included in the Pfafflin study.

Pretraining in which the subject was instructed to observe differences in figures that would later be relevant to a discrimination task has resulted in facilitation of discrimination learning when compared with pretraining without instructions to observe differences (Goss, 1958). Pretraining by prior exposure of stimuli with instructions to look for difference has often resulted in positive transfer equal to that obtained by pretraining by associating verbal responses to discriminanda that would later be used as stimuli in a discrimination task requiring another class of responses (Arnoult, 1957). Pretraining in which S is instructed to observe both the relevant discriminanda and the relevant response produced by E has resulted in significantly more positive transfer to criterion tasks than conditions requiring S to construct responses which are then differentially reinforced (Kaess & Zeaman, 1960; and Cook & Spitzer, 1960). It was one of the purposes of the present study to test a prediction of facilitation of discrimination learning following prior exposure to the same stimuli when no indication of a following task is given.

Attneave (1957b) pretrained subjects by having them draw from memory a figure which represented a "central tendency" of the array of figures used in the transfer task. He called this figure

representing the central tendency of the discriminanda the "prototype" figure or the "class-schema". After adjusting obtained scores on the discrimination task to equate for correlated differences in performance on a prior test of "Memory for Landmarks", he found significant improvements in scores on the transfer task when compared with groups similarly pretrained on unrelated figures. No interaction of pretraining with complexity of figure was observed.

Differential reinforcement in the ordinary sense is not introduced by E in the various pretraining conditions described above which require S to observe or draw stimuli without direction S to respond to relevant differences in the discriminanda. Current functionalist and formal theories of discrimination have assumed reinforcement to be a basic parameter of discrimination learning (Estes, 1960). Estes has recently suggested a modified view to account for learning on the nonreinforced trial. He observes that, "the response, correct or incorrect occurring on a test trial has some probability of becoming conditioned to the stimulus pattern present on the trial" (1960, p. 339). Conditioning by contiguity could account for discrimination learning under conditions of nondifferential reinforcement such as those reported by Arnoult (1956b).

The possibility of positive transfer following pretraining on a prototype figure (Attneave, 1957b) gives rise to the question of the identity of the associations formed that might facilitate discrimination learning. The prototype figure in Attneave's study was so constructed as to include the irrelevant elements, i.e. the

elements which did not correlate consistently with reinforcement in the transfer situation. A group of studies shows facilitation of discrimination learning following pretraining consisting of learning paired associate terms that are different from the responses required in the discrimination task (Arnoult, 1957). These findings may suggest a basis for predicting positive transfer following prototype training. In prototype pretraining as conducted by Attneave S was trained to make a response during pretraining by drawing from memory the stimulus components that would be irrelevant (not correlated consistently with reinforcement) during the discrimination task. If learning this response during pretraining served the same function as the responses learned during the pretraining in the paired-associates pretraining studies, it would be expected that there would be facilitation in learning to discriminate between the irrelevant stimulus elements (which had acquired an associated response in pretraining) and the relevant stimulus elements (which had not been present during pretraining).

Some authors have conjectured that familiarity by prior experience with a representative object from a group of stimulus objects which have some similarities but some differences will lead to an increased ease of discrimination among the group of objects (Bartlett, 1932; Woodworth, 1938; Hebb, 1944). With the exception of Attneave's study which included pretraining of a "prototype" figure (1957b), this prediction seems not to have been tested formally. It was, therefore, one of the purposes of the present study to test the predicted facilitation of discrimination learning

following exposure to a "prototype" figure, which was a figure representative of the stimulus figures to be discriminated.

Relevant and Irrelevant Cues in Prototype Pretraining. Attneave (1957b) proposed that "(a) the central tendency of the class, (b) how its members may differ from one another; and (c) the dispersion of the class" may be learned in pretraining.

The "central tendency" of the class includes the invariant elements of a class of stimuli to be discriminated. These invariant elements do not correlate with reinforcement and so they are the irrelevant elements in a given discrimination task. These irrelevant elements become adapted in the course of successful discrimination (Bourne & Restle, 1959).

In order that S may learn how members of a class of stimuli may "differ from one another" and how the "class of stimuli" is "dispersed" in a discrimination task, it is required that he learn of the characteristics of those elements that correlate with reinforcement contingencies. The elements that covary consistently with reinforcement contingencies become conditioned during the course of successful discrimination learning.

One purpose of the present study was to test the hypothesis of increased facilitation of discrimination learning as more of the relevant and irrelevant stimulus elements are exposed prior to the discrimination task.

The hypothesis predicts greater facilitation of discrimination for each of the following conditions: (1) prior exposure of figures containing no relevant nor irrelevant components, (2) prior exposure

of a figure containing only the irrelevant components (or "central tendency of the class"), (3) prior exposure of figures containing both irrelevant and relevant components (indicating "how the members may differ" and "the dispersion of the class").

The first hypothesis to be tested by this study may be stated as follows: variation in errors in discrimination learning is related to pretraining conditions as an inverse function of the degree of similarity of the two stimulus arrays.

Relevant and Irrelevant Cues in Discrimination Learning. Discrimination learning in recognition, paired-associates and motor response tasks using figural stimuli is generally a negatively accelerated function of the number of relevant cues (French, 1954; Trabasso, 1960; Hillex, 1960). The same relationship obtains when irrelevant cues are reduced (Arnoult & Price, 1961; French, 1954).

Facilitation of discrimination learning by the addition of relevant cues within a given stimulus dimension such as the dimension of shape may be limited by the information processing capacity of the organism with performance reaching an early asymtope and then decreasing with added cues (Rappaport, 1957; Attneave, 1960; Miller, 1956; and French, 1953). However adding relevant cues by adding independently varying relevant dimensions such as adding relevant color cues to relevant shape cues seems to be facilitory as a negatively accelerating function of added dimensions without such a restriction on the number of added cue dimensions (Bourne & Haygood, 1961). Even a small change in the configuration of a shape results in many changes in several potential stimulus dimensions including

line lengths, slopes, angle sizes, and relative distances. It was assumed that these stimulus dimensions were functionally independent so that the effects of adding such cues would facilitate discrimination learning. It was one of the purposes of the present study to test this predicted facilitation.

The second hypothesis to be tested by this study was that the number of errors in the discrimination task is an inverse function of the number of relevant components of the stimulus array.

With respect to the addition of irrelevant cues most of the studies of this variable in discrimination learning have employed irrelevant cues that vary independently from frame to frame (Bourne & Restle, 1959). However, the effect on discrimination of an increase in the irrelevant components that are redundant, i.e., common to all members of a complex stimulus, needs further study. The present study was designed to test the prediction of facilitation of discrimination learning as a function of decreased irrelevant cues when the irrelevant cues are redundant from frame to frame.

The third hypothesis to be tested in this study was that the number of errors in the discrimination learning task is a direct function of the number of irrelevant components of the stimulus array.

Attneave (1957b) tested for interaction between pretraining and "complexity" of the figure as indicated by the number of vertices in polygon stimulus figures. He found no interaction. The figures sampled in the latter experiment had 12 and 6 defining points respectively but the ratio of relevant to irrelevant

content was held approximately constant at one to three. Attneave's speculation that the subject may learn "how" and "how much" the members of a stimulus class may vary during exposure to the stimuli prior to discrimination learning suggests that as the relevant content is decreased and the irrelevant content is increased it would be increasingly difficult to learn these things about the stimulus array. It was one of the purposes of this experiment to test for an interaction between pretraining and the relevant and irrelevant content of the stimulus array.

The fourth hypothesis to be tested in this study was that interaction results from relatively fewer errors on the discrimination task following pretraining on conditions that include a higher ratio, i.e., more irrelevant and less relevant, of irrelevant cues.

Summary of the Experimental Hypotheses

The survey of the above studies indicates the need for replication and expansion of findings related to pretraining with shapes. The problems investigated in this study concern the difficulty of discrimination learning of complex pictorial stimuli when the number and proportion of cues relevant to the discrimination task are varied during observation pretraining and during the subsequent task.

The specific statements of hypotheses that were derived from the examination of the studies cited above are summarized below:

1. Variation in errors in discrimination learning is related to pretraining conditions as an inverse function of the degree of similarity of the two stimulus arrays.

2. The number of errors in the discrimination task is an

inverse function of the number of relevant components of the stimulus array.

3. The number of errors in the discrimination learning task is a direct function of the number of irrelevant components of the stimulus array.

4. Interaction results from relatively fewer errors on the discrimination task following pretraining on conditions that include a higher ratio, i.e., more irrelevant and less relevant, of irrelevant cues.

CHAPTER II

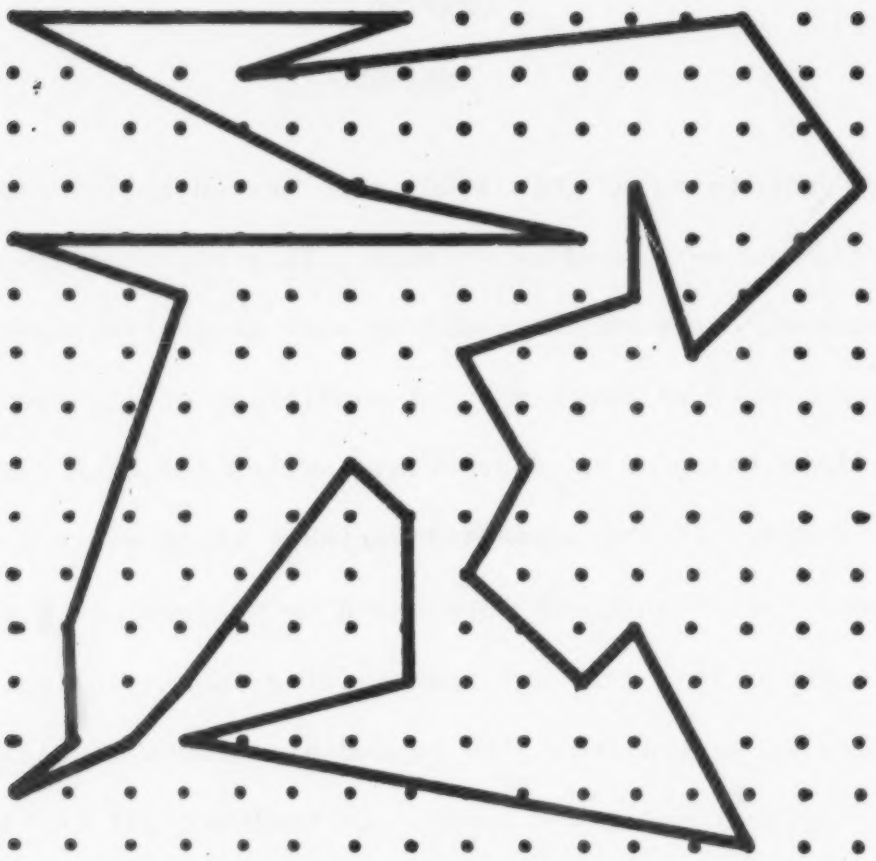
METHOD

The hypotheses of this study were tested in two experiments. Random figures were used as stimuli. They were constructed so that systematic variations could be made to provide appropriate stimuli for each of the 5 x 3 x 2 conditions of the factorial design. The closing of an appropriate switch for each figure provided a measure of the dependent variable which was automatically recorded. The stimuli were presented by projection on a rear view screen. Projection intervals and reinforcement contingencies were automatically controlled. The second experiment consisted of a partial replication of the first. It included all but two of the pretraining conditions. The design permitted all the hypothesis to be tested in each of the two experiments.

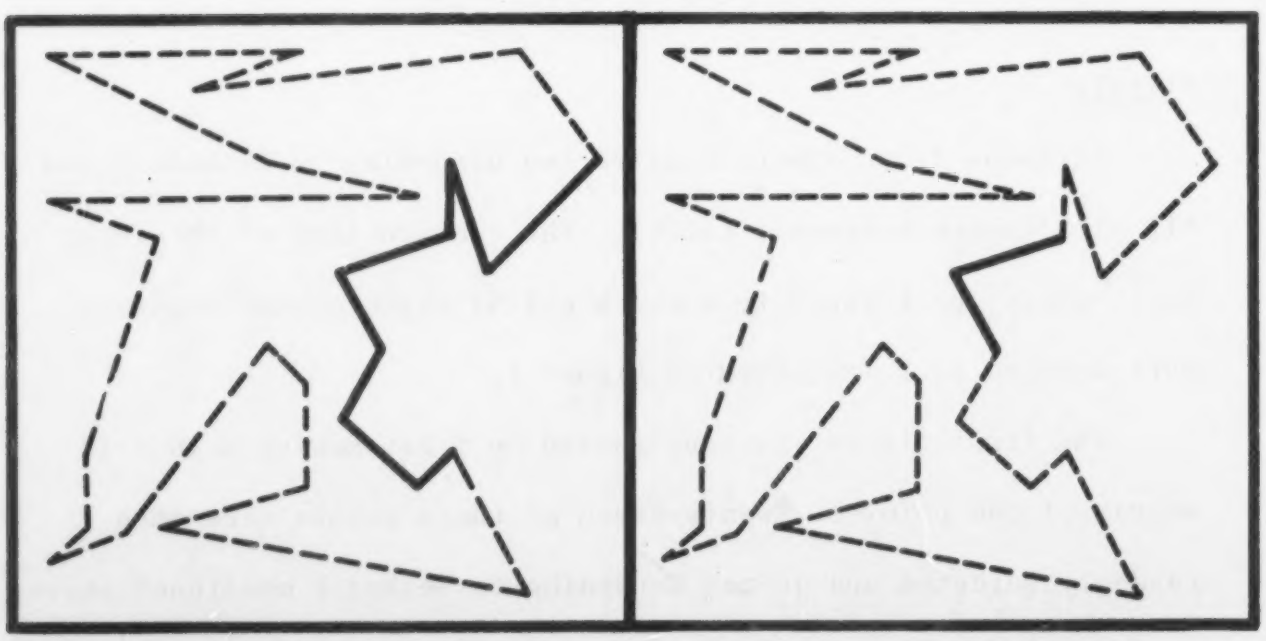
Stimuli

Stimulus figures were constructed according to Methods I and VII of Attneave & Arnoult (1956). The construction of the three basic prototype figures from which all 51 experimental figures were derived is illustrated in Figure 1.

The first figure was constructed by first making a 16 x 16 matrix of 265 points. Twenty-seven of these points were then randomly selected and joined according to Method I mentioned above, to form what is referred to as the 27-point prototype figure. A 9-point and a 3-point prototype figure were derived as follows from the 27-point prototype figure. First, one of the 27 points



27-Point Prototype



9-Point Prototype

3-Point Prototype

Fig. 1. Construction of prototype figures. (Matrix points and dash lines did not appear on prototype stimulus figures.)

was randomly selected with the restriction that it be at least one matrix point removed from any other point defining the figure or any point on the perimeter of the matrix. This point was called the focal point. All lines on the 27-point prototype figures beyond the fourth point in either direction from the focal point were deleted to form the 9-point prototype. Similarly, all lines beyond the first point in either direction from the focal point were deleted to form the 3-point prototype figure. The first eight variations of each of the three prototype figures, as shown in Figures 2, 3 and 4, were then constructed. The eight points in the matrix most adjacent to the focal point of each prototype defined the new locations of that point in the eight variations of each prototype figure. This constituted one figural array of eight figures derived from a 27-point prototype with one point varied through eight locations. Another similar array of eight figures derived from the 9-point prototype figure and a third similar array from the 3-point prototype figure. These three groups of eight figures respectively were designated as Conditions 27-1, 9-1 and 3-1.

Conditions 27-3, 9-3 and 3-3 were also constructed from the prototypes shown in Figure 1. The eight variations of each prototype were constructed by allowing the focal point and the two most adjacent points in the figure to be assigned randomly to one of the adjacent points in the matrix. These new locations were then connected to form new variations of the 27-point prototype figure. The first eight variations of the 27-point prototype so constructed,

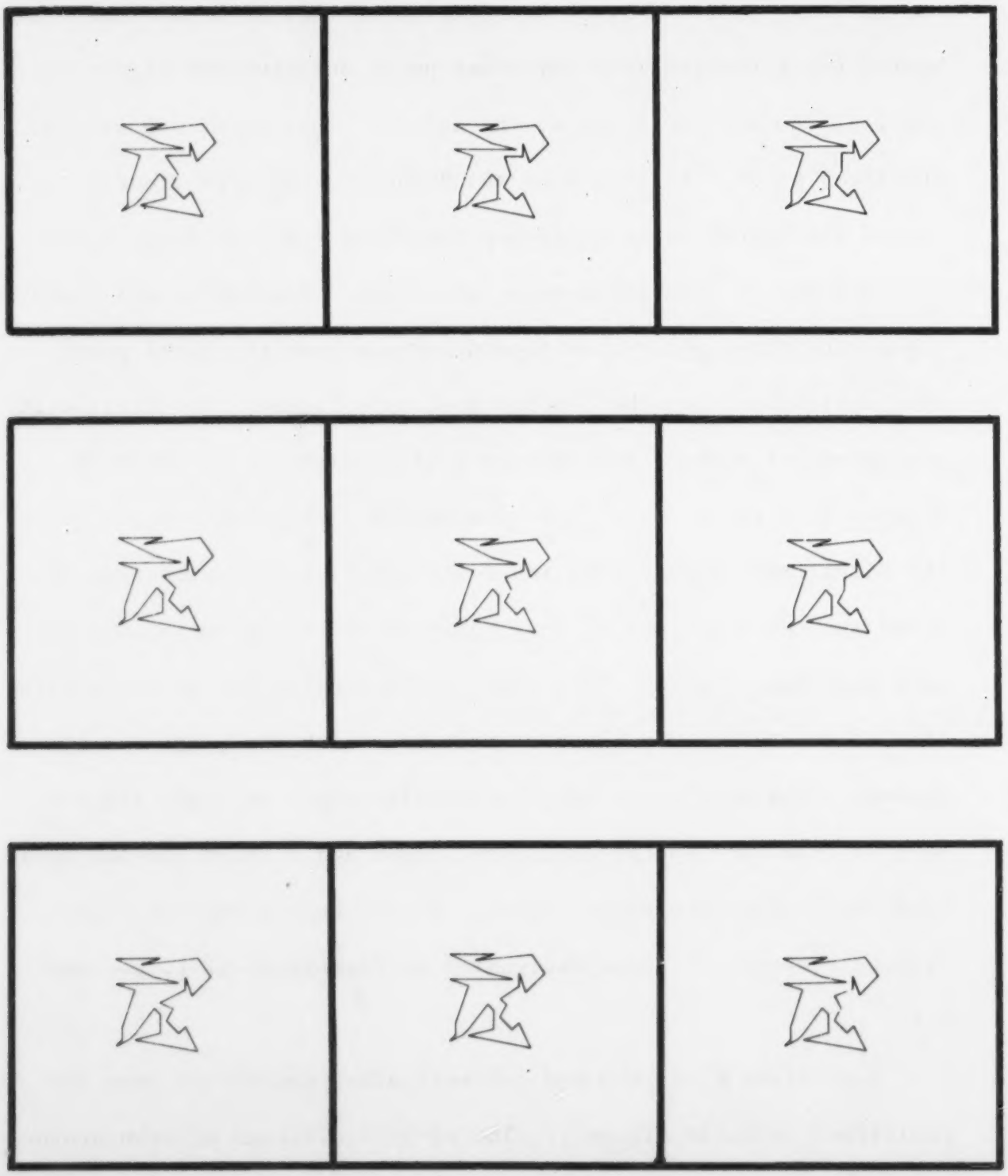


Fig. 2. Condition 27-1. Prototype (center) and 27-1 array.

Fig. 3. Condition 9-1. Prototype (center) and 9-1 array.

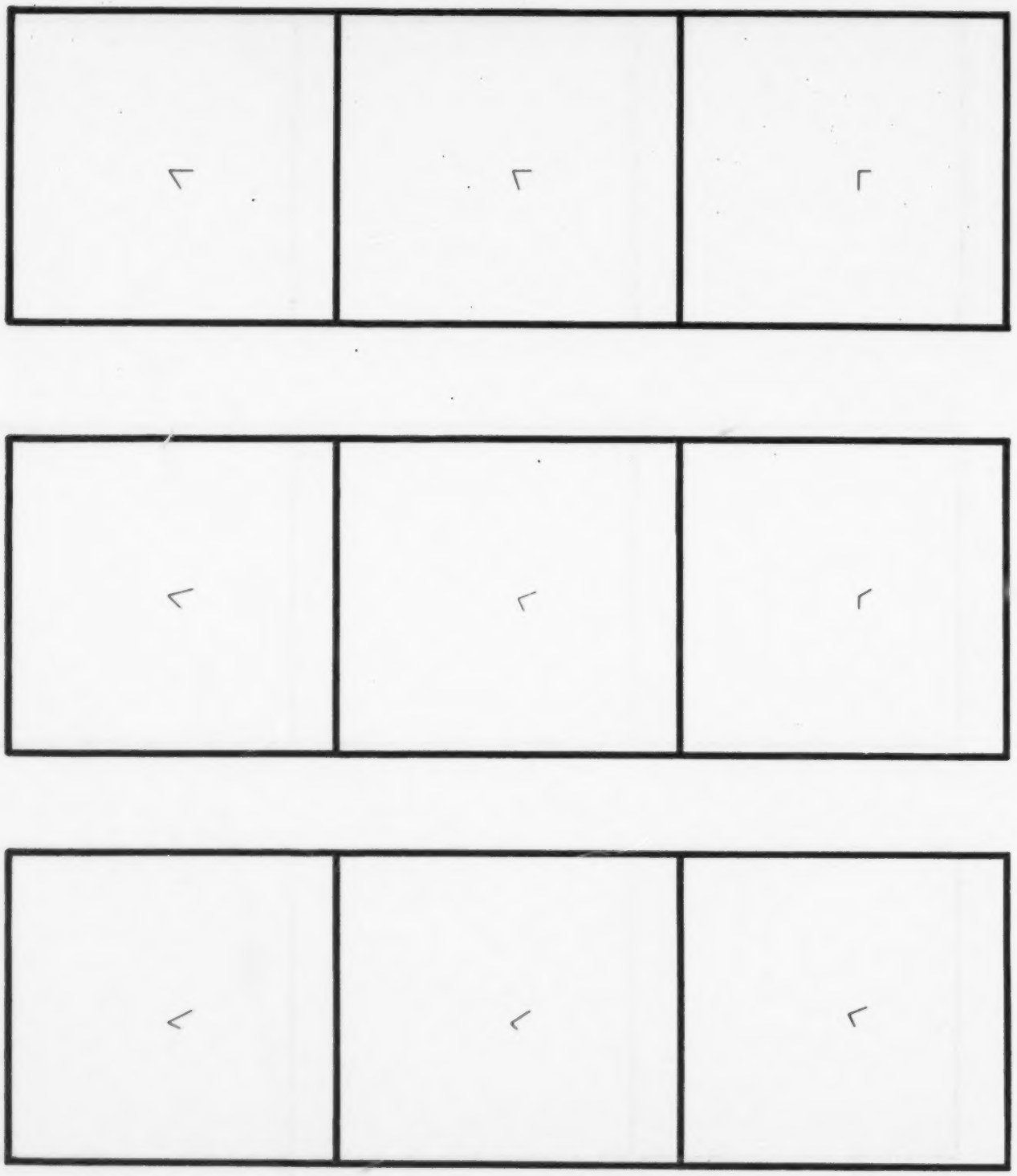


Fig. 4. Condition 3-1. Prototype (center) and 3-1 array.

that did not include intersecting lines, constituted the stimuli for a given array. The identical eight variations were made of the 9-point and 3-point prototype figures. This resulted in the stimulus arrays referred to as Conditions 27-3, 9-3, and 3-3. These conditions are illustrated in Figures 5, 6 and 7, respectively.

The range of variations, of the irrelevant cue dimension from 3 points to 27 points was prompted by failure in Attneave's study to demonstrate effects related to irrelevant content using a narrower range of variation. The assumption was made that cues sampled would be proportional to the number of points defining a figure. This was based in part upon the finding of Attneave that the number of points was highly related to judged complexity of figures (1957a). The assumption was also made that equal psychological intervals between levels of relevant or irrelevant cues are achieved by exponential increases in the number of points describing the relevant or irrelevant position of the figure.

The control figures consisted of 16 figures which had been constructed according to Method I of Attneave & Arnoult, but that had not been derived from the same matrix or number of defining points as the experimental figures. The experimental figures were line figures while the control were white shapes on dark backgrounds. The selected figures were obtained from among those used by Arnoult (1956a), and Attneave (1957b) (Figure 8). These figures were selected to provide one group of subjects (control group) with the same procedural and environmental conditions during pretraining as the experimental groups with the exception that the stimulus figures

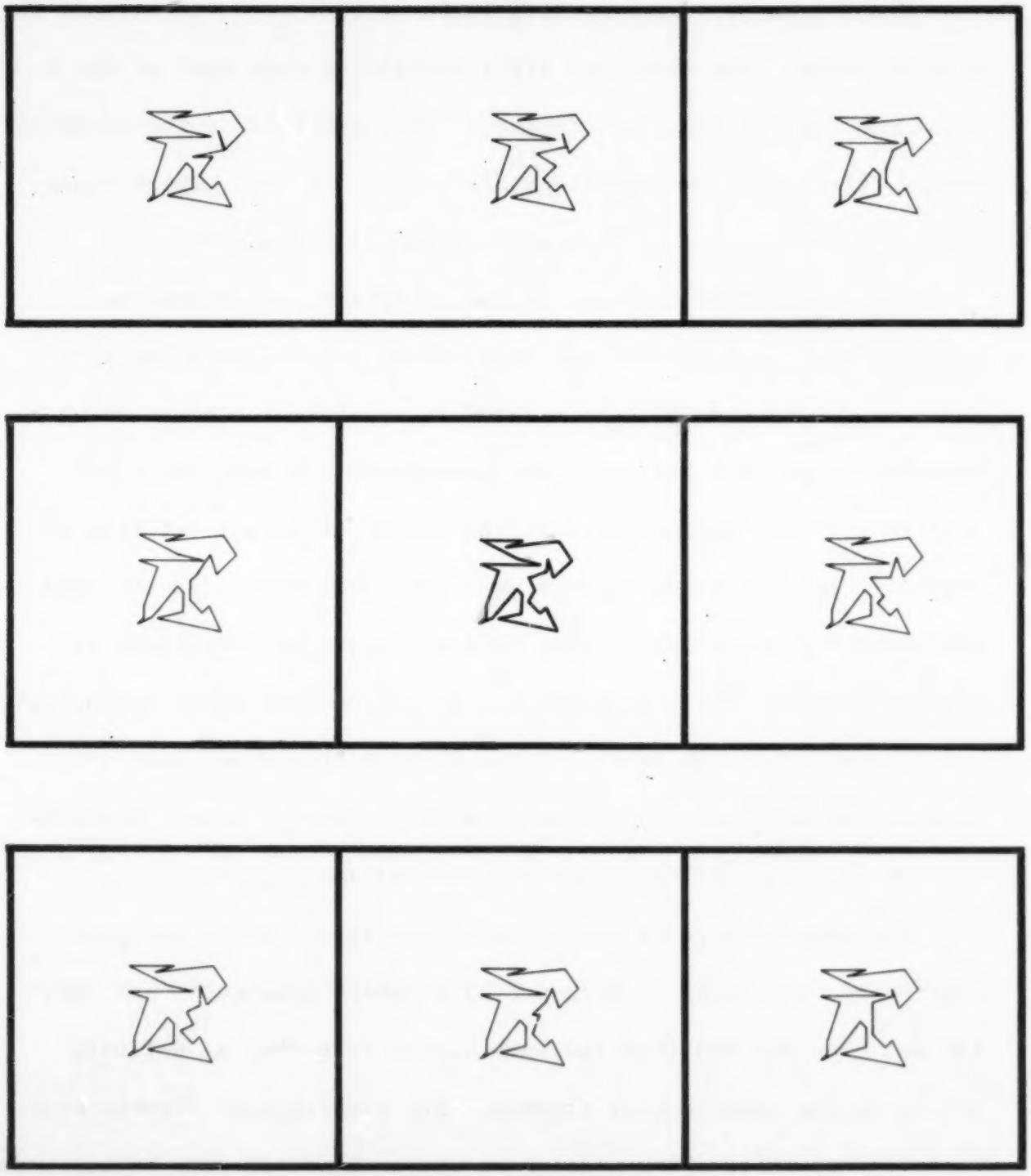


Fig. 5. Condition 27-3. Prototype (center) and 27-3 array.

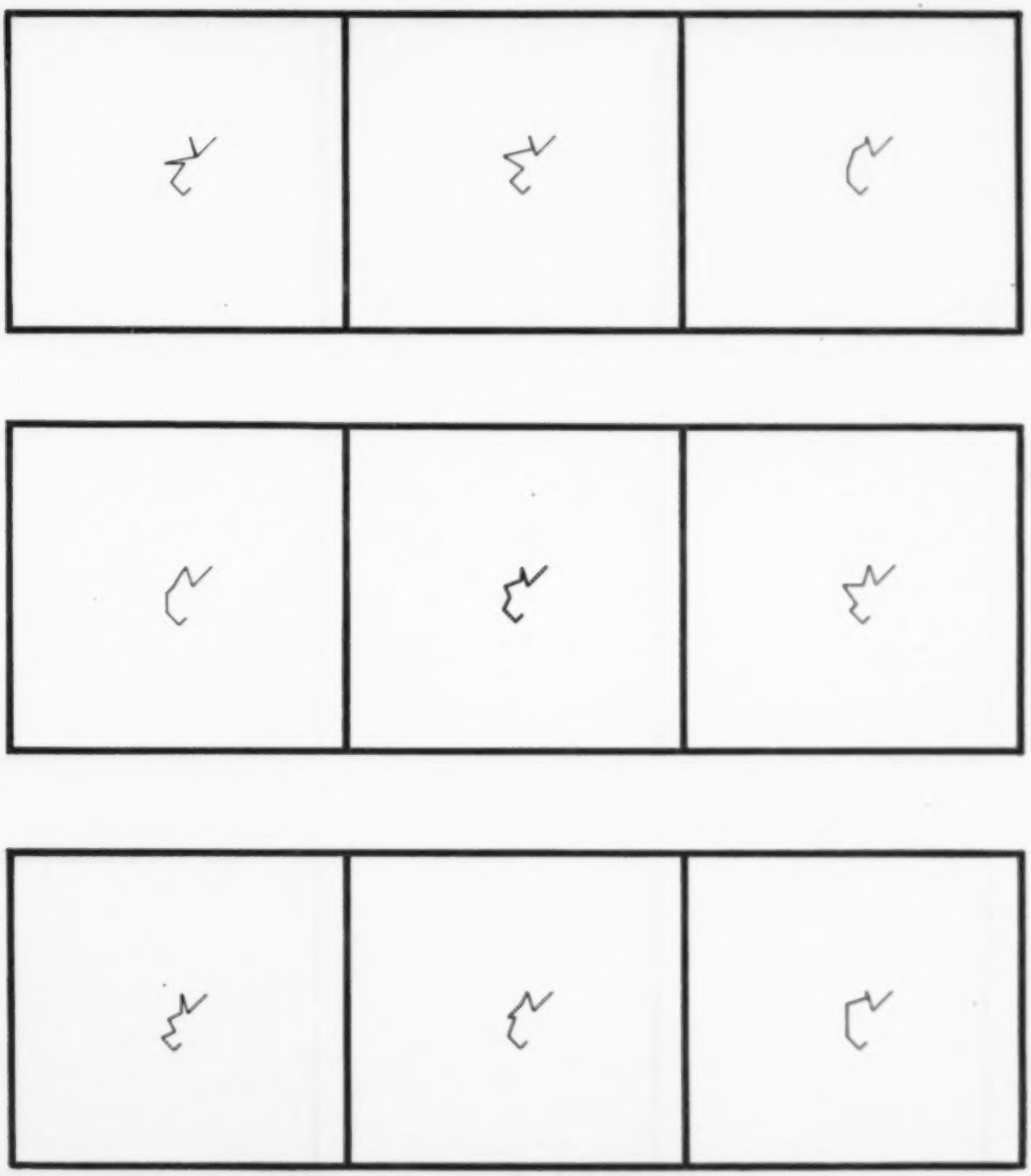


Fig. 6. Condition 9-3. Prototype (center) and 9-3 array.

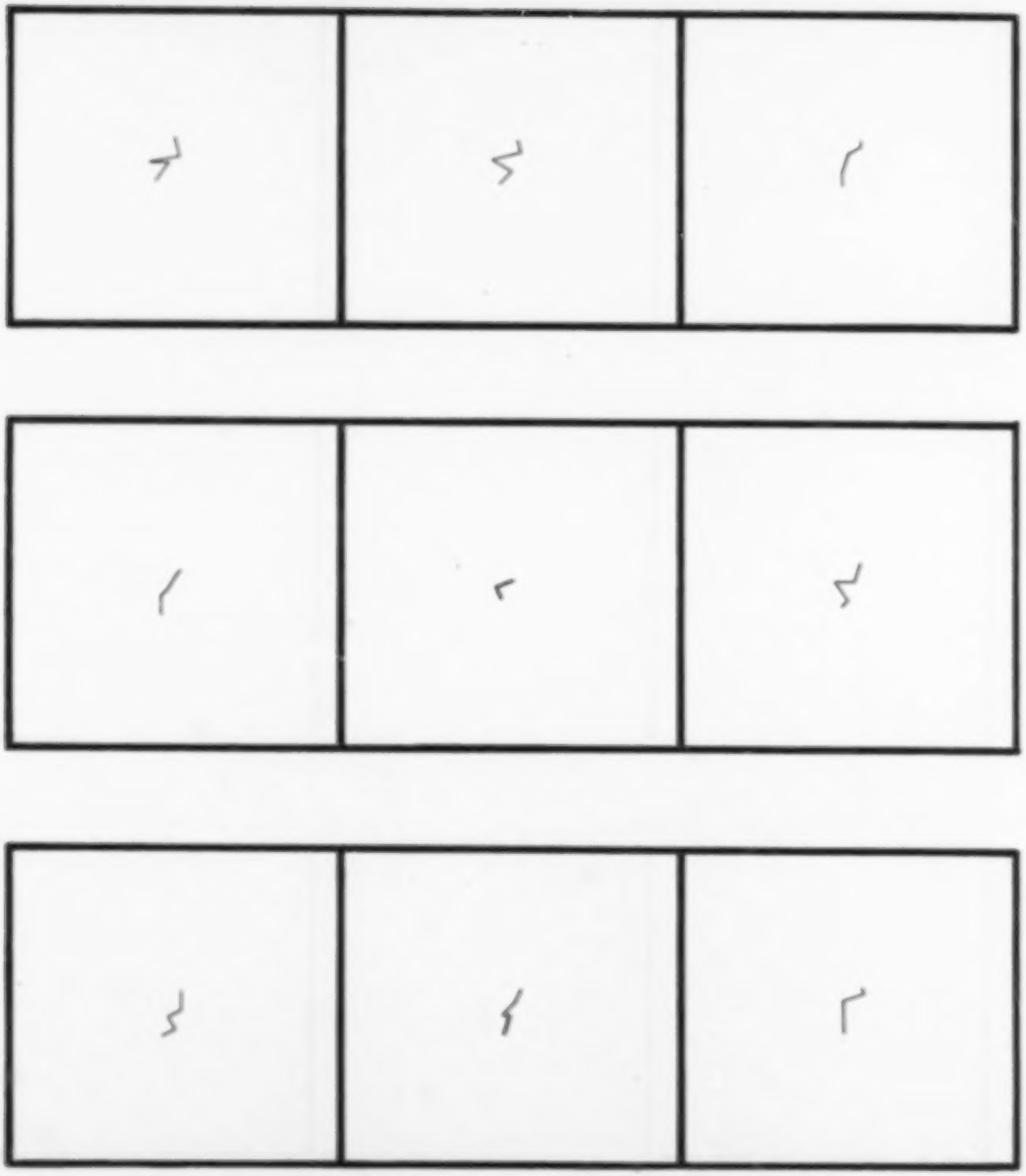
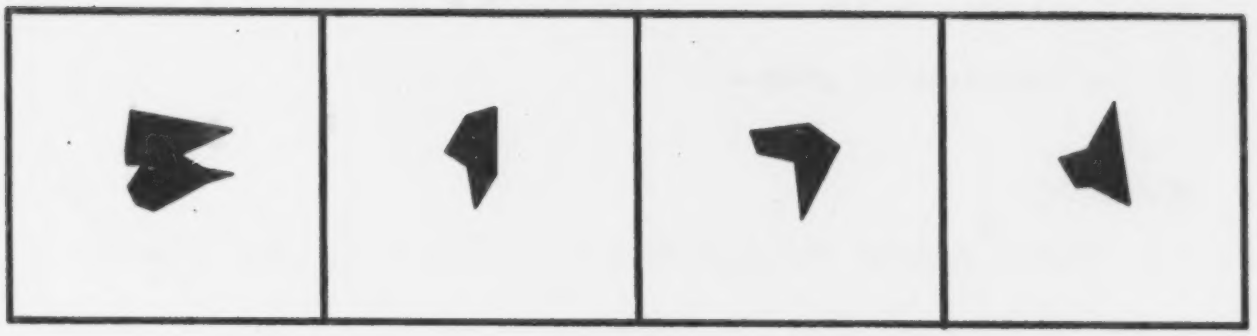
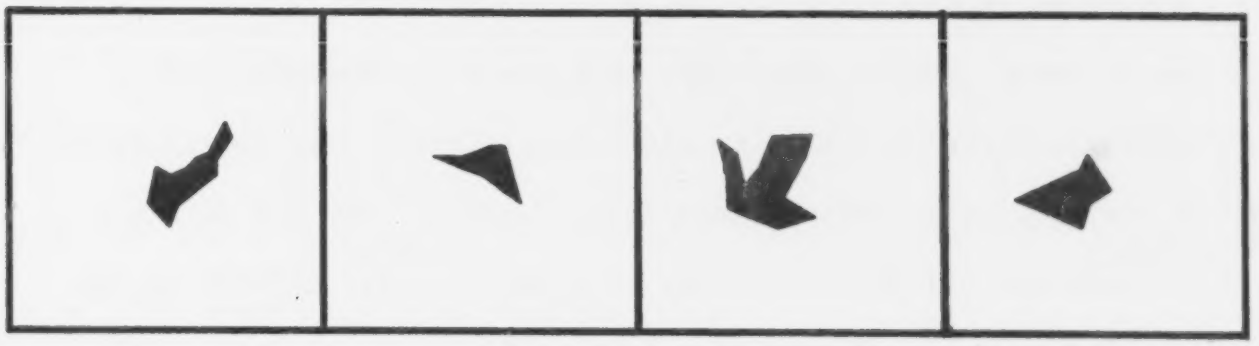
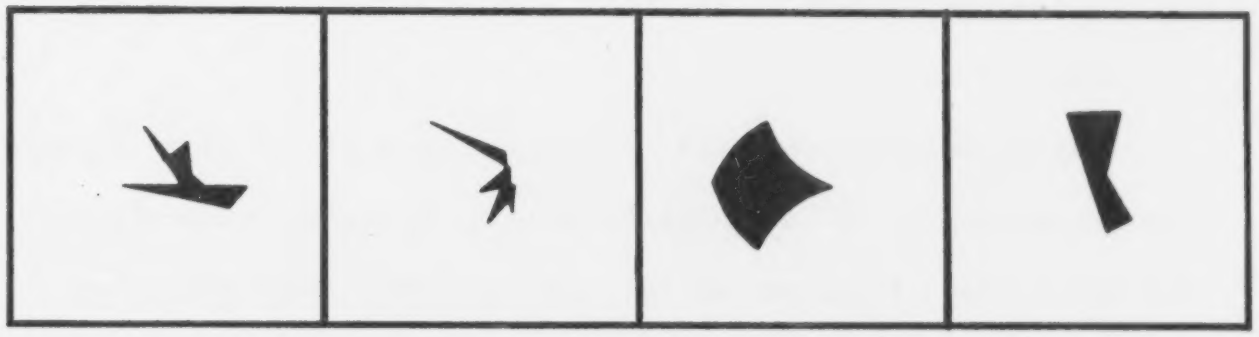


Fig. 7. Condition 3-3. Prototype (center) and 3-3 array.







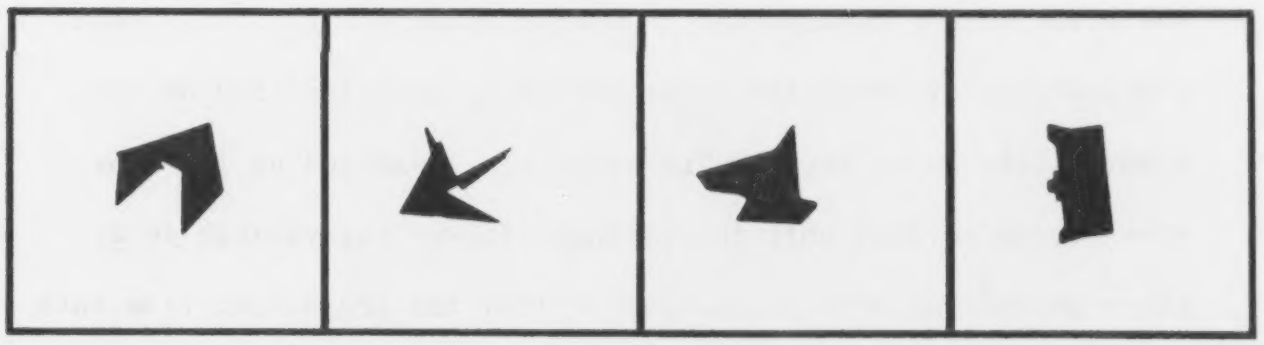


Fig. 8. The control figures.

would not include the relevant and irrelevant components presented to the experimental groups.

Apparatus

Figure 9 shows the apparatus as viewed by E. The stimulus materials were presented by a Sarkes-Tarzian projector (A) which permitted random access to any given stimulus by closing switches on a remote control panel (B). The projector was modified by adding a Gerbrand's pulsing electronic timer (C) which activated a stepping relay (D), so that the projection lamp was on six seconds and off three seconds. The maximum search cycle of the projector was two and a half seconds which permitted slides to be in position by the end of the three-second interval between projections.

The slides were composed so that one area of the slide allowed the projection of the stimulus pattern while another area allowed the projection of any one of the eight possible combinations of projected light resulting from making any of three code areas of the slide either transparent or opaque (Figure 10). These eight combinations of projected light served to identify each of the eight slides in an array. The slide was projected on the rear-view screen so that only the stimulus figure was visible to S. Three photocells were positioned so that the projection from each of the three code areas (A, B and C) would activate a separate relay. A Gerbrand's event recorder recorded on three separate pens the closing of the three photocell relays and thus identified the stimulus. The reinforcement light was connected to the photocell

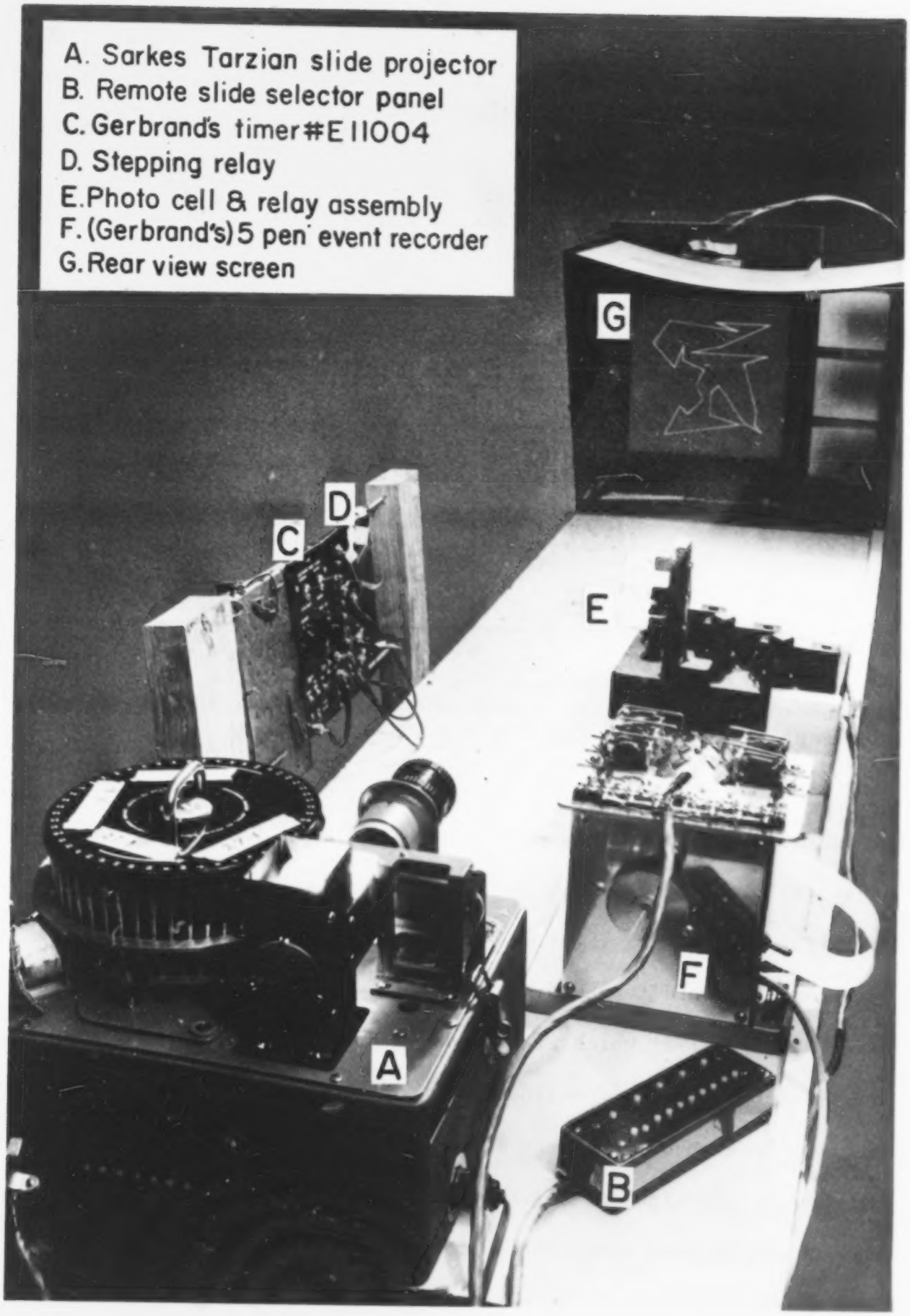


Fig. 9. Apparatus as viewed by experimenter.

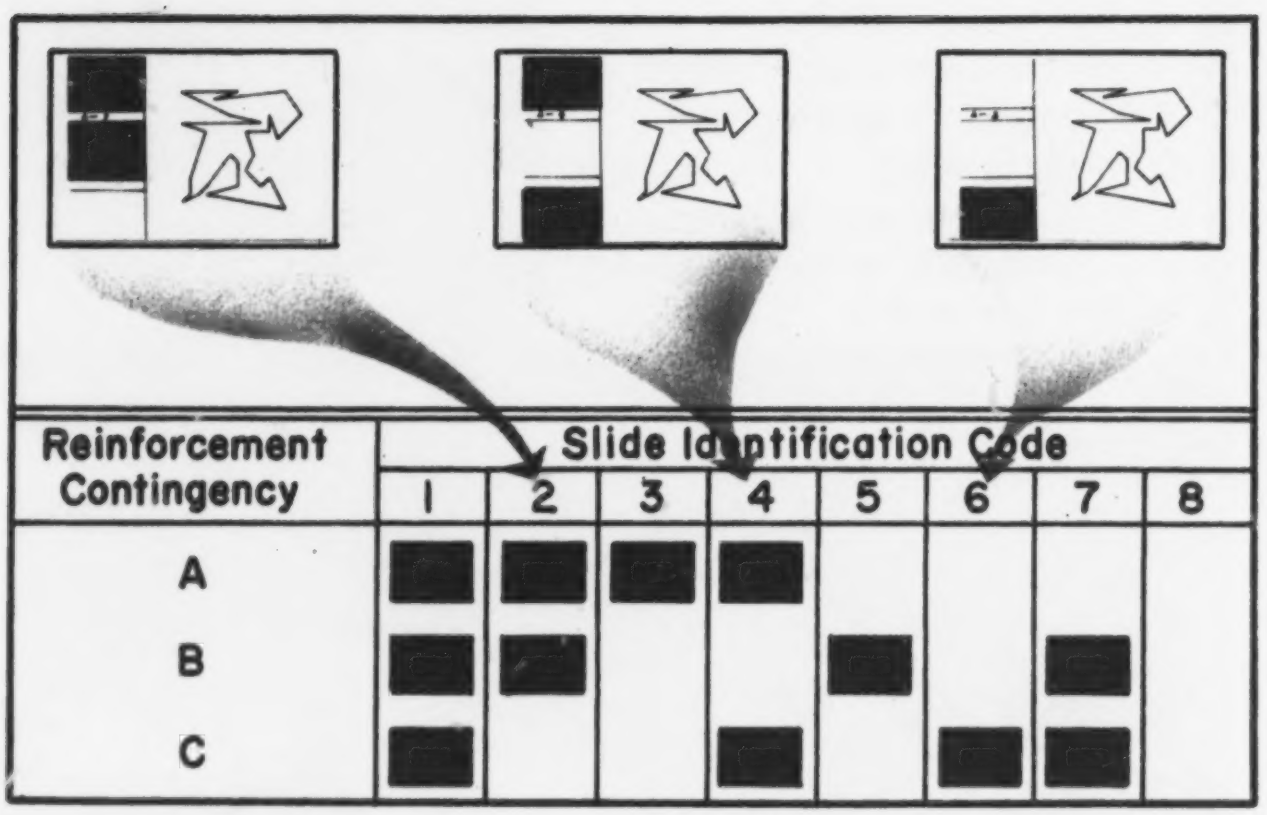


Fig. 10. Light codes employed to identify slides and provide reinforcement contingency. (Samples above of slides showing arrangement of light code and figure.)

circuit so that when light was projected in one of the light code areas the closing of one of the two response switches would turn on the light and when no light was projected in that area, closing the other switch would turn on the light. A switch in the circuit allowed E to select which light code position would determine when the reinforcement light could be turned on by a given response switch. In each of the three light code areas light was projected for four of the eight slides. Light code positions A and C were used in the present study and position A differed from C in that four of the eight slides required a different switch to turn on the reinforcement light. Two additional pens, D and E, were activated

by the response panel switches indicating respectively reinforced responses, i.e., responses which turned on the reinforcement light, and all responses, reinforced or nonreinforced. Relays were introduced into the circuit to permit the reinforcement lamp to be turned on only during the first response to a given projection. The reinforcement light stayed on as long as S held the switch closed while a given slide was projected. See Appendix B for the wiring diagram.

Figure 11 shows the apparatus as viewed by the subject. The stimuli were projected onto a 16" x 16" rear-view screen (G) which was positioned at eye level for a seated S. A light providing the reinforcing event (H) was centered two inches above the screen. On the table separating S and the screen were mounted two laterally-placed lever action switches which served as the response panel (I). The only light source in addition to the projected stimulus was one 40-watt fluorescent light mounted on the ceiling. A floor plan showing the arrangement of the apparatus is presented in Figure 12.

Subjects

The Ss in Experiment I were 132 students from Indiana University High School and included both boys and girls of the tenth, eleventh and twelfth grades. Data from 12 Ss were discarded because of apparatus failure or procedural errors. Subjects were assigned randomly to the experimental conditions with the restriction that one replication be completed before the next was begun. All subjects were volunteers and were paid one dollar for participating.

In Experiment II, 73 boys and girls from the ninth grade of Indiana University Junior High School served as subjects. Data from one subject was discarded because of apparatus failure.

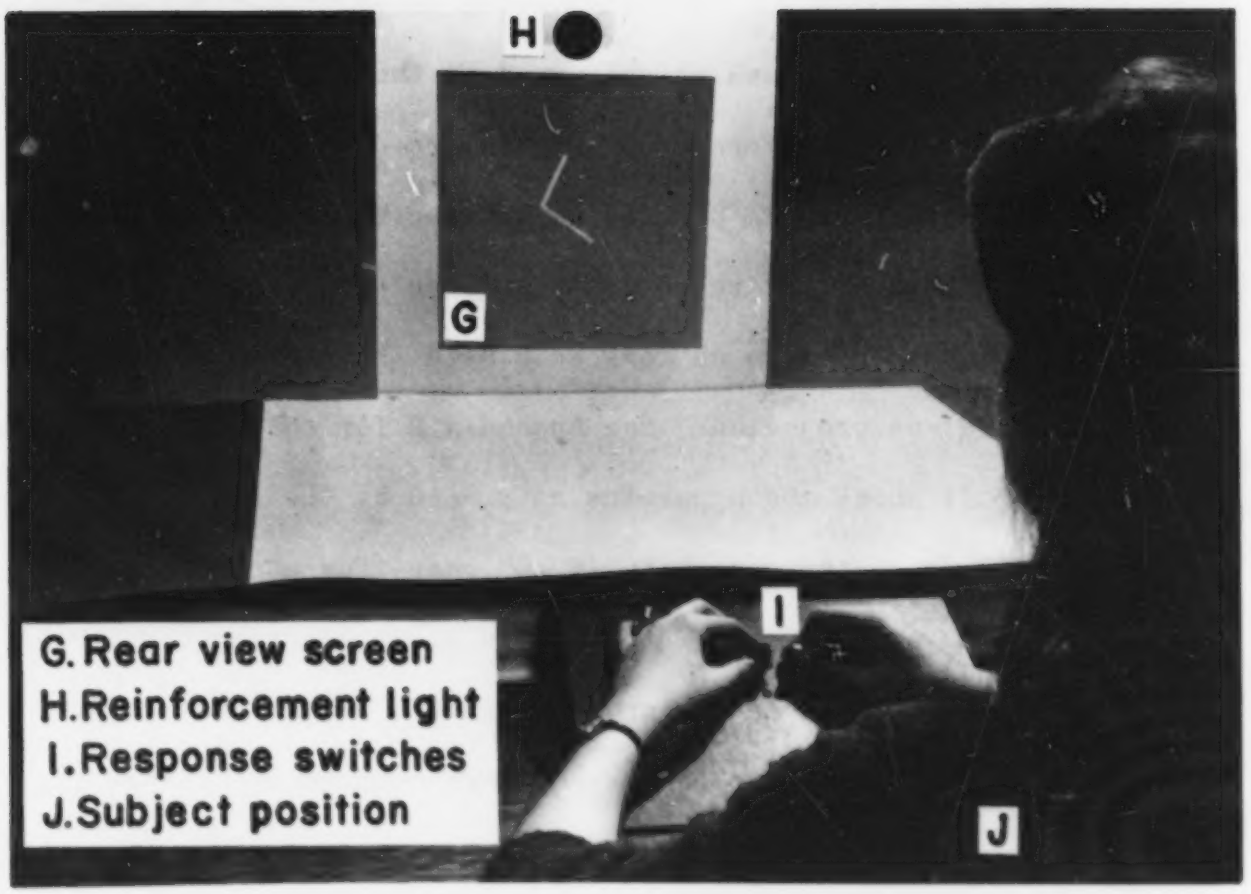


Fig. 11. Apparatus as viewed by subject.

Procedure

Each S was seated about 36" in front of the screen and was instructed regarding the pretraining task as follows: "A series of figures will be projected onto this screen. You are to look carefully at the figures projected onto this screen. The figures will be projected a number of times. Your only task is to look carefully each time a figure is projected...." No indication of a subsequent task was given. (See Appendix C for complete procedure and instructions.)

In pretraining, S was shown 96 projections of either the eight

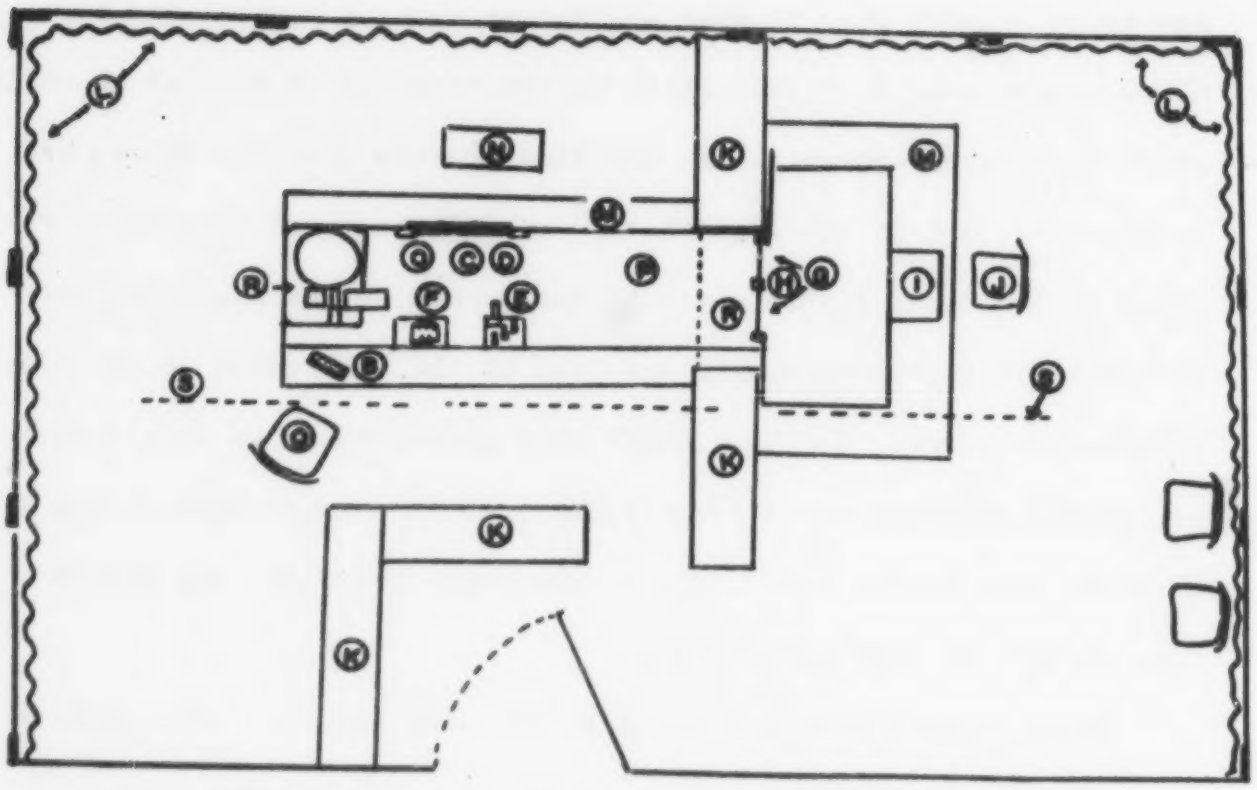


Fig. 12. Floor plan of experimental laboratory.

figures of an array, the members of which he would later learn to discriminate (P_8), or two (P_2), or four (P_4) of that array, the prototype figure of that array (P_p), or the 16 control figures (P_c). The figures were presented in randomly ordered permutations of the given set of figures with the result that each control figure was presented 6 times (P_c), each figure from a group of eight 12 times (P_8), each figure from a group of four 24 times (P_4), each figure from a group of two 48 times (P_2), and a prototype figure 96 times (P_p). The figure was projected for six seconds with three-second invervals between slides. Approximately one minute after the completion of pretraining S was given instructions to learn which of the two switches would turn on the light above the screen when a given slide was presented. The subject was encouraged to make only

one response, but also to make a response even if he were not sure. He was instructed to decide which switch to press as soon as he could after the figure appeared. He was finally told that the object was to learn to turn on the light each time. S was first allowed to respond to the first figure until he had turned on the light and then he immediately proceeded with the rest of the 96 figures in the discrimination array. The 96 figures were presented in 12 trials with one random permutation of the 8 figures in the array constituting a trial. One minute later, the figures were presented another 96 times under the same conditions.

These figures were presented in the same order as the complete array (P_8) in the pretraining sequence. The subject was then paid and instructed not to discuss the details of the experiment with other students.

Two of the four subjects in each cell were randomly assigned to reinforcement contingency A and the other two to reinforcement contingency C.

Design

In Experiment I four subjects were assigned randomly to each of the thirty cells in a simple 5 x 3 x 2 factorial design (Table 1). The five pretraining conditions (P_c, P_p, P_8, P_4, P_2) were described above. The three irrelevant cue conditions (I_{27}, I_9, I_3) were defined by the 27-, 9- or 3-point prototype from which the stimulus arrays were derived. The two relevant cue conditions (R_1, R_3) consisted of stimulus arrays having one point or three adjacent points varied from figure to figure.

Table 1

Factorial Design and Number of Subjects per Cell in Experiment I

Pretraining condition	Figural condition						Row total
	Irrelevant						
	I_3		I_9		I_{27}		
	Relevant		Relevant		Relevant		
	R_1	R_3	R_1	R_3	R_1	R_3	
Control (P_c)	4	4	4	4	4	4	24
Prototype (P_p)	4	4	4	4	4	4	24
Array of 8 (P_8)	4	4	4	4	4	4	24
Array of 4 (P_4)	4	4	4	4	4	4	24
Array of 2 (P_2)	4	4	4	4	4	4	24
Column total							
Relevant (R_1)	20		20		20		60
Relevant (R_3)		20		20		20	60
Irrelevant (I)	40		40		40		120
All conditions	120						120

Experiment II differed only in that the pretraining condition P_2 and P_4 were omitted resulting in a 3 x 3 x 2 design.

CHAPTER III

RESULTS

Experiment I

The total number of errors over trials 2 through 24 was obtained for each S. The errors on the first trial were omitted since S had no basis for making other than random responses on that trial. The mean errors for the two reinforcement contingencies were found to be non-significantly different ($t = .67$) so these scores were pooled within cells. The means for cells and conditions are shown in Table 2. (Raw data are reported in Appendix D.)

Table 2

Mean Errors on Discrimination Task
(Experiment I)

Pretraining condition	Figural condition						Row mean
	Irrelevant						
	I_3		I_9		I_{27}		
	Relevant		Relevant		Relevant		
	R_1	R_3	R_1	R_3	R_1	R_3	
P_c	39.5	35.8	61.8	39.5	61.8	18.8	42.8
P_p	30.8	33.3	30.4	33.3	43.8	38.5	38.9
P_8	45.0	22.0	49.8	34.0	55.0	42.0	41.2
P_4	30.8	29.0	54.2	33.5	50.4	28.5	37.8
P_2	43.8	27.5	35.8	29.5	55.8	35.8	38.8
Column mean							
Relevant (R_1)	38.0		51.1		54.1		47.7
Relevant (R_3)		29.4		34.0		32.7	32.1
Irrelevant (I)	33.7		42.5		43.5		39.9
All columns	39.9						39.9

Significant heterogeneity of variance from cell to cell was not demonstrated (χ^2 = 41.32; 29 df; $P < .10$) (Snedecor, 1946). An

analysis of variance was then performed which yielded the results summarized in Table 3.

Table 3

Analysis of Variance on the Number of Errors in Experiment I

Source	df	Mean square	F
Relevant (R)	1	7379.0	22.96**
Irrelevant (I)	2	1154.3	3.59*
Linear	1	1881.8	5.86*
Quadratic	1	426.7	1.33
Pretraining (P)	4	107.4	.33
R x I	2	425.7	1.32
R x P	4	179.8	.56
I x P	8	200.4	.62
R x I x P	8	274.6	.85
Error	90	321.4	

**P <.01

*P <.05

The mean error scores for the relevant conditions were 47.7 for R_1 and 32.1 for R_3. These mean scores yielded a significant F of 22.96 (df 1/90; P <.01). This indicates that, as the number of relevant cues was increased, the errors in discrimination learning decreased. The mean error scores for the irrelevant conditions were

I_3, 33.7; I_9, 42.5; and I_{27}, 43.5. Again the means were found to vary significantly ($\underline{F}$ = 3.59; df 2/90; $P < .05$). Partitioning of the variance associated with the irrelevant factor into the linear and quadratic components shows that only the linear component is significant ($\underline{F}$ = 5.86; df 1/90; $P < .05$). An examination of the mean differences by the Duncan range test indicates however that only the differences between the means of I_3 and I_9 and between I_3 and I_{27} were significant ($P < .05$), while the difference between I_9 and I_{27} was not significant. Increases in the number of irrelevant cues present in the array was associated with an increase in errors.

The $\underline{F}$ of 0.33 for the pretraining factor indicates that the difference among the mean number of errors following these conditions are not statistically significant. All interactions with pretraining, P x I, P x R, and P x I x R yielded $\underline{F}$ ratios less than one.

Errors as a function of each of the main experimental conditions is graphically summarized in Figure 13.

The decision was made to carry out a replication of those pretraining conditions that had been compared in previous studies, control (P_c), identical (P_8) and prototype (P_p) was planned. An inspection of the data suggested that one source of uncontrolled variation may have been related to differences in performance by subjects of different ages. The methods and procedures of the replicated parts were the same. This allowed the pooling of results within cells for the two experiments which resulted in greater precision in the analysis.

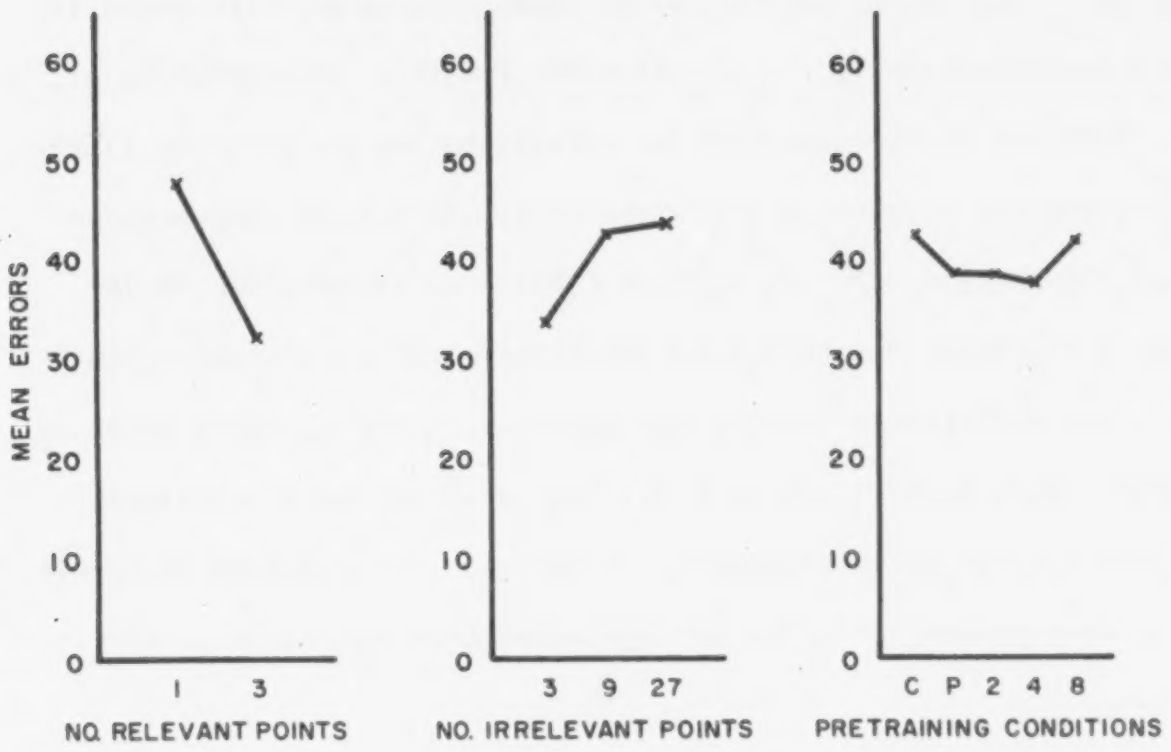


Fig. 13. The effects of the relevant, irrelevant and pretraining conditions upon discrimination learning: Experiment I.

Experiment II

In Experiment I, the hypothesis of facilitation of discrimination learning through a prior exposure to the discriminanda had been made. This hypothesis was not supported. Three pretraining conditions were chosen for a replication study including the control, the prototype and the complete array conditions. These pretraining conditions were tested over the same figural variations as were employed in Experiment I. The purpose of this experiment was to determine whether the findings in Experiment I would again be obtained with more precise analysis.

Identical methods to those used in Experiment I were followed

with the following variations: 73 ninth-grade students served as paid volunteer subjects. Data from one subject was discarded due to an apparatus failure. With the elimination of two pretraining conditions of Experiment I which were P_2 and P_4, a 3 x 3 x 2 factorial design resulted.

The errors for each subject were again recorded for the 24 trials (Appendix D). Since S had no basis for non-random responses on the first trial, only the errors made on the last 23 trials were used in the analysis. Differences between reinforcing contingencies were again found to differ non-significantly ($t = .40$) so the results were pooled within cells. Mean error scores were computed for cells and experimental conditions and are presented in Table 4.

Table 4

Mean Errors on Discrimination Task: Experiment II

Pretraining condition	Figural condition						Row mean
	Irrelevant						
	I_3		I_9		I_{27}		
	Relevant		Relevant		Relevant		
	R_1	R_3	R_1	R_3	R_1	R_3	
P_c control	45.8	32.8	80.3	39.3	57.3	37.3	48.8
P_p prototype	37.0	30.0	54.8	52.3	69.0	57.8	50.2
P_8 array of 8	48.0	21.0	50.3	26.3	60.5	53.3	43.2
Column mean							
Relevant (R_1)	43.9		61.8		62.3		56.0
Relevant (R_3)		27.9		39.3		49.5	38.9
Irrelevant (I)	35.8		50.6		55.9		47.4
All columns	47.4						47.4

Variance within cells was found not to be significantly heterogeneous ($P < .20$) (Snedecor, 1946). The results of the analysis of variance are summarized in Table 5. All sources of significant variance in Experiment I yielded significant F ratios in Experiment II.

Table 5

Analysis of Variance on the Number of Errors
(Experiment II)

Source	df	Mean square	F
Relevant (R)	1	5202.00	13.65**
Irrelevant (I)	2	2697.35	7.08**
Linear	1	4840.00	12.58**
Quadratic	1	355.00	.93
Pretraining (P)	2	321.75	.84
R x I	2	148.20	.39
R x P	2	498.89	1.31
I x P	4	629.40	1.65
R x I x P	4	270.67	.71
Error	54	381.00	

** $P < .01$

Conversely no comparison that was statistically non-significant in Experiment I was significant in this experiment. The only change in the findings was that higher levels of confidence were justified by the F ratios testing the mean variance for the irrelevant (I) factor. All significant differences were in the directions predicted. The reliability of findings in Experiment I was supported without exception.

The F ratio testing mean variance of pretraining conditions was .84 and was not statistically significant. As in Experiment I,

no significant differences were obtained between the pretraining conditions nor did pretraining interact with either of the other experimental factors.

The obtained means for the relevant cue conditions were 55.9 for R_1 and 38.19 for R_3. The F ratio of 13.65 (df 1/54; $P < .01$) shows a significant difference between them. Again an increase in the number of relevant figural cues was associated with fewer errors.

The means for the relevant cue conditions were 35.8 for I_3, 50.5 for I_9, and 55.8 for I_{27}. The F ratio showed the difference between these means to be significant ($F = 7.08$; df 2/54; $P < .01$). Partitioning of this variance showed that the linear component was significant at the one per cent level ($F = 12.58$; df 1/54; $P < .01$), while the quadratic component resulted in an F ratio of only .93. The Duncan range test comparing these means showed I_3 to be different significantly from I_9 ($P < .02$) and from I_{27} ($P < .01$), but I_9 and I_{27} did not differ significantly. Except for higher levels of confidence associated with these findings, all the findings associated with the irrelevant cue conditions support the findings of increased errors associated with increases in the number of irrelevant cues. The interaction between relevant and irrelevant cue conditions was small and insignificant in both Experiment I and II. Means for the three main effects are compared graphically in Figure 14.

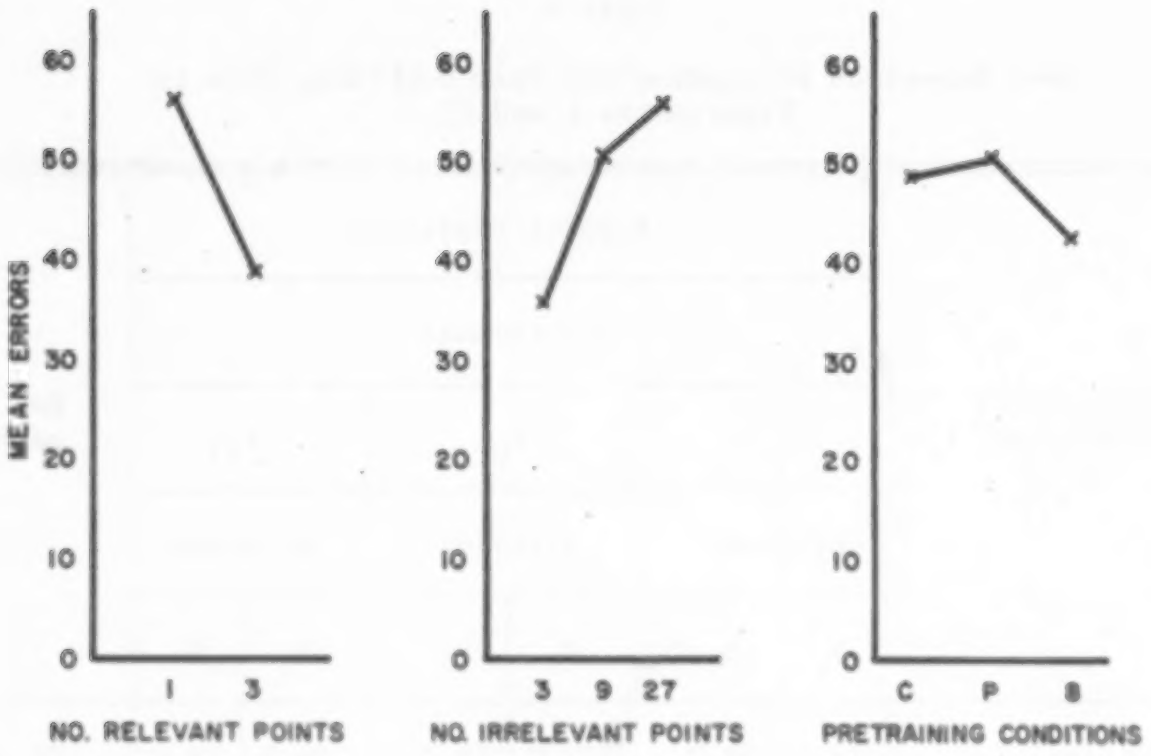


Fig. 14. The effects of the relevant, irrelevant and pretraining conditions upon discrimination learning: Experiment II.

Combining the Results of Experiment I and Experiment II

Experiment II was designed to be a replication of part of Experiment I. This permitted a combination of data which increased the precision of the analysis. The differences between the two experiments were treated as block effects with the scores from Experiment I being assigned to one block and scores from Experiment II the other. The results of this combination are reported in Tables 6 and 7. As in the case of Experiments I and II the relevant and irrelevant main effects yielded significant variation ($P < .01$), while pretraining yielded non-significantly different means. The only additional finding was in connection with block differences which proved to be significantly different ($\underline{F} = 4.37$; df 1/125;

Table 6

Mean Errors on Discrimination Task Combining Data in Experiments I and II

Pretraining condition	Figural condition						Row mean
	Irrelevant						
	I_3		I_9		I_{27}		
	Relevant		Relevant		Relevant		
	R_1	R_3	R_1	R_3	R_1	R_3	
P_c control	42.6	34.3	71.0	39.4	59.5	28.0	45.8
P_p prototype	33.9	31.6	54.4	42.8	56.4	48.1	44.5
P_8 array of 8	46.5	21.5	50.0	30.1	57.8	47.6	42.3
Column mean							
Relevant (R_1)	40.9		58.5		57.9		52.4
Relevant (R_3)		29.1		37.4		41.2	36.0
Irrelevant (I)	35.1		48.0		49.5		44.2
All columns	44.2						44.2

$P < .05$). The mean for Experiment I was 41.0 and for Experiment II was 47.4. This difference was consistent with the differences associated with age that were noticed but not controlled or tested in Experiment I.

Table 7

Analysis of Variance on the Number of Errors for Combined Data in Experiments I and II

Source	df	Mean square	F
Relevant (R)	1	9817.44	29.59**
Irrelevant (I)	2	3029.25	9.13**
Linear	1	4991.81	15.05**
Quadratic	1	1066.69	3.22
Pretraining (P)	2	154.52	.45
Block[a]	1	1450.34	4.37*
R x I	2	252.23	.76
R x P	2	842.46	2.54
R x I x P	4	391.63	1.18
I x P	4	457.18	1.38
Error	125	331.76	

** $P < .01$

[a] Block I: Experiment I omitting P_2 and P_4
Block II: Experiment II

A graphic comparison of the means for the main effects of Experiments I and II is presented in Figure 15.

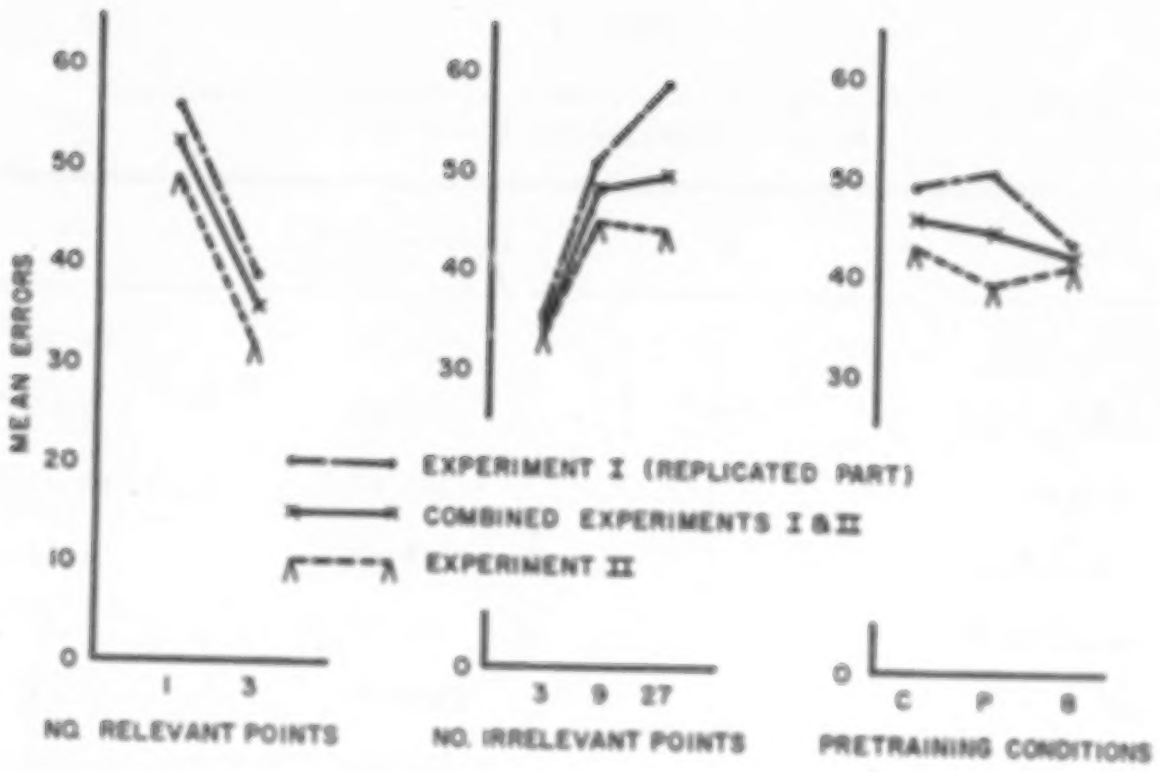


Fig. 15. The effects of the relevant, irrelevant and pre-training conditions upon discrimination learning: Replicated part of Experiments I and II.

CHAPTER IV

DISCUSSION

The hypotheses of facilitation of discrimination learning as a function of increased relevant and decreased irrelevant cues present in an array of complex figural discriminanda were confirmed, in both Experiment I and Experiment II. These findings are generally compatible with other empirical findings and theoretical predictions related to discrimination learning.

Although no hypothesis was made in these studies concerning the interaction between relevant and irrelevant cue content, this interaction was tested in the course of the analysis and found to be insignificant. In a discrimination learning experiment reported by Rappaport (1958) the addition of relevant cues resulted in interference with learning when a minimum level of irrelevant cues were present. The addition of relevant cues facilitated learning at higher levels of irrelevant cue content. This interaction between relevant and irrelevant cue factors at low levels of irrelevant cue content was not obtained in either Experiment I or II. The stimulus exposure interval was 6 seconds in these studies while the interval was only .5 seconds in the Rappaport study. However, a longer time interval of 3 seconds was used in a concept learning problem which as in the present study resulted in a failure to confirm interference effect of adding relevant cues at a minimal irrelevant cue level (Bourne and Haycock, 1960).

A hypothesis of an inverse relationship between irrelevant components in the stimulus array and discrimination learning was

confirmed in both Experiments I and II by the finding of a significant linear component of the variance assocciated with the irrelevant factor. Inspection of the mean differences, however, resulted in finding that while the mean differences were all in the predicted order of magnitude only the difference between I_3 and I_9 and that between I_3 and I_{27} were significant. Failure to find significant difference between I_9 and I_{27} in both experiments suggests the value of testing the relationship between irrelevant cue content and discrimination learning over a wider range of irrelevant cue content and with a larger sample of figures.

The hypotheses of the facilitation of discrimination learning through prior exposure to stimuli that differ with respect to their degree of similarity to the discriminanda, uniformly failed to be confirmed in either Experiment I or II.

This result included the finding that the comparison of the control, i.e., the dissimilar stimulus array pretraining condition and the identical stimulus array condition, yielded results that were not significantly different. The same result had been reported by Goss (1958) and Cantor (1955) in previous studies involving similar pretraining conditions. In all these cases, pretraining that did not require differential responses to the parts of the stimulus array that would later be relevant did not result in facilitation of discrimination when the control was presentation of stimuli that differed from that used in the transfer task. One report of facilitation of discrimination following presentation of stimuli with instructions to observe was reported by Arnoult (1957b) but

his control was the estimated random performance of the discrimination task rather than performance following observation of some different array of figures.

The finding of no difference between the prototype pretraining condition and the control pretraining condition is not consistent with the findings reported by Attneave (1957b). His initial findings showed no difference between the prototype and control pretraining conditions. However the adjusted scores reflecting initial differences in his subjects on a test of "Memory for Landmarks" which correlated with performance on the experiment did show a facilitating effect associated with the prototype condition. According to Attneave his experiment was the first to test under controlled conditions Hebb's prediction of facilitation of discrimination learning following pretraining on a prototype figure. If his findings can be shown to be reliable in replication studies then the failure of the present experiments to confirm his studies must be accounted for. One of the differences was that his pretraining procedure was five successive viewings of the prototype figure each of which was followed by an attempt to reproduce the figure by drawing it. This procedure had been shown to facilitate later discrimination learning more than pretraining by observation with instructions to try to retain the image between projections (Arnoult, 1957). The prototype pretraining condition in the present studies was more like the pretraining by observation procedure described above. If this difference in procedure accounts for the difference then it would suggest the hypothesis that more intense pretraining with the prototype would facilitate discrimination learning.

The absence of interaction effects of any of the main factors with the pretraining factor indicates that the number or ratio of relevant cues in the discriminanda was not associated with unusual variations in scores on the various pretraining conditions. The hypothesis predicting that pretraining with similar figures would be most effective with figures that had high irrelevant and low relevant components was not confirmed.

CHAPTER V

SUMMARY AND CONCLUSION

Two experiments were conducted to determine the effect upon a discrimination learning task of: (1) prior exposure to figures that varied with respect to similarity to the figures to be discriminated; (2) varying figures with respect to the number of components that was relevant, i.e., correlated with reinforcement in the learning task; and (3) varying figures with respect to the number of components that was irrelevant.

Experiment I and II employed the same procedures and stimuli. Experiment II served essentially as a replication of Experiment I. The stimuli were line shapes that were constructed by varying systematically a figure drawn according to a method for generating random shapes. The sets of figures to be discriminated varied from condition to condition with respect to the number and proportion of figural elements (lines, points, angles, lengths, etc.) that were relevant or irrelevant. Relevant cues and irrelevant cues were independently varied resulting in two relevant cue conditions and three irrelevant cue conditions.

These figural variation conditions were used within five conditions of pretraining. Pretraining consisted of instruction to observe carefully the figures with no indication of a following task. The figures used in pretraining varied with condition. They consisted of figures with the following relationship to the figures that would be used in the discrimination task: (1) the array of eight figures that would be presented in the discrimination task,

(2) four of the eight figures, (3) two of the eight figures, (4) a prototype stimulus representing the geometric central tendency of the array of eight figures, and (5) a sample of polygon figures drawn from another population of figures used as the control stimuli.

The response used in the discrimination task was closing one of two lever action switches while each of the eight figures used in a given condition was on the screen. The right switch turned on the reinforcement for four figures that were randomly selected from the eight figures in the array. The left switch turned on the light for the other four.

Both experiments supported the hypotheses of facilitation of discrimination as a function of increased relevant and decreased irrelevant figural cues. Neither experiment confirmed the hypothesis of facilitation as an inverse function of the degree of similarity between the stimuli present in the pretraining and discrimination task.

Conclusions

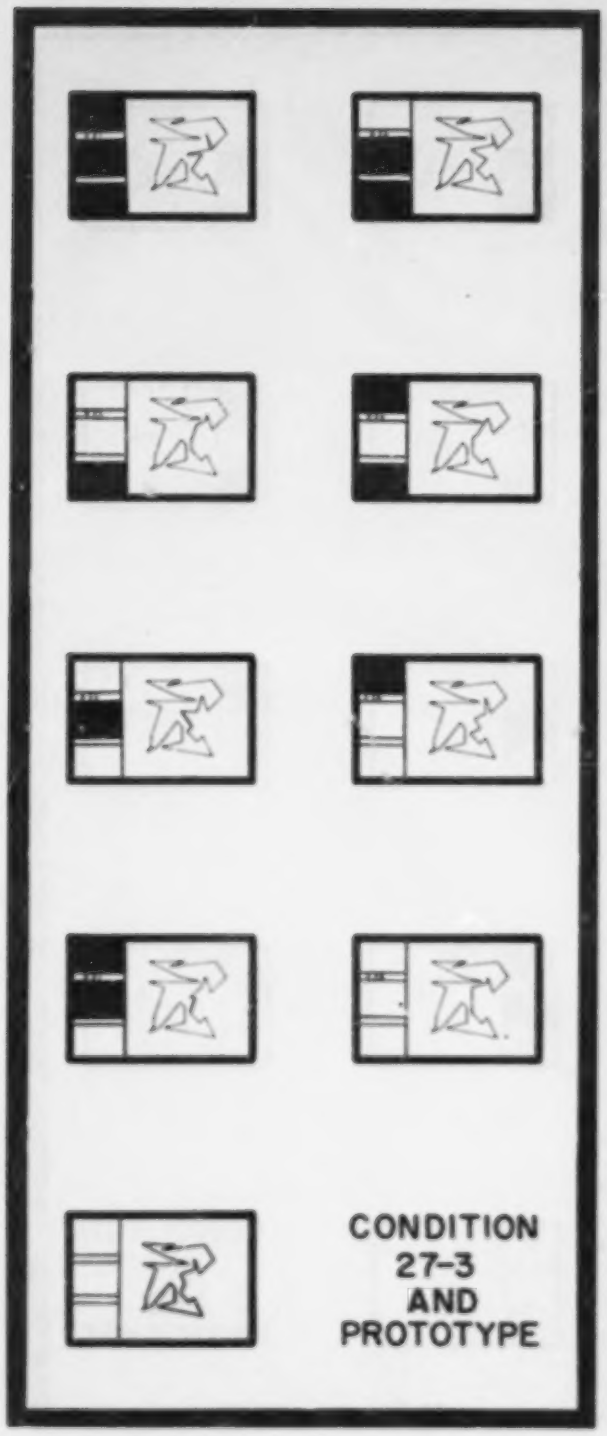
Two problems were of general concern in this study. The first was the problem of identifying significant relationships between reinforcement and physical components of complex pictorial stimuli in discrimination learning. The line shapes used as stimuli in this study were varied by adding some lines that correlated with reinforcement and others that did not. Adding lines correlated with reinforcement facilitated discrimination learning while the addition of lines not correlated with reinforcement interfered with learning. These findings were consistent with previous findings regarding

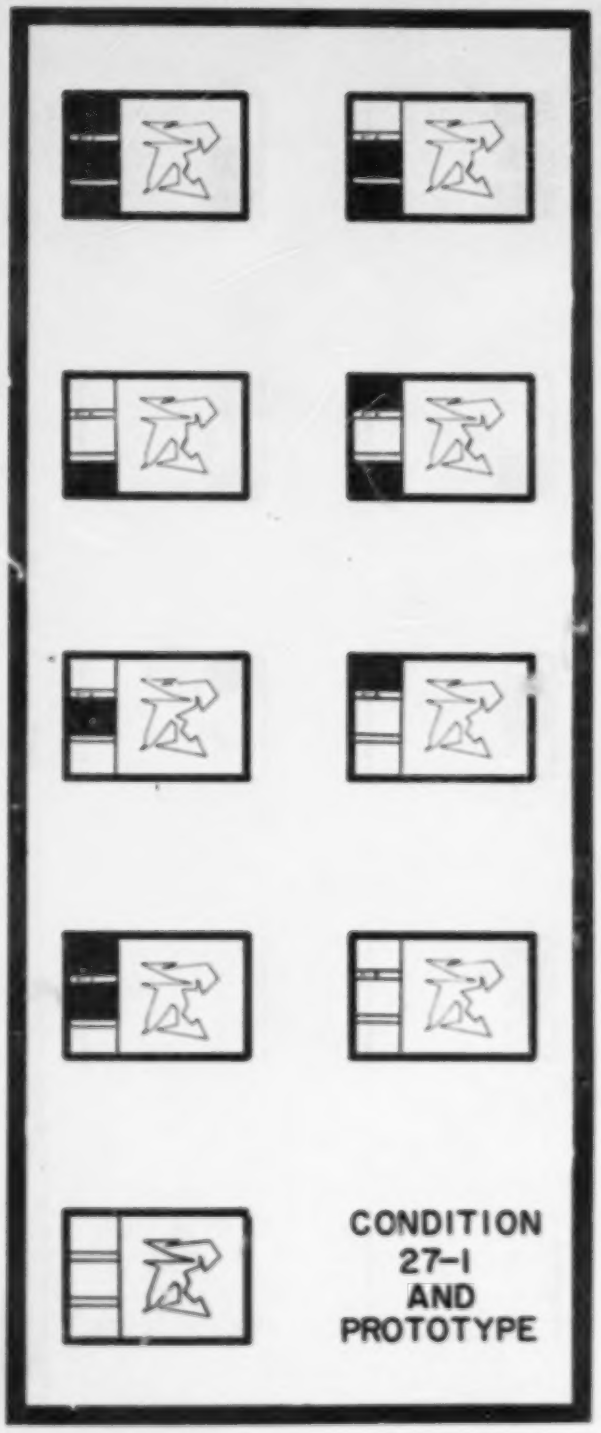
discrimination learning of simpler stimuli. The usefulness of the procedures used in this study for identifying significant relationships between reinforcement and physical components of complex pictorial stimuli is indicated for extensions of this study.

The second problem was that of identifying variables related to prior experience with pictorial stimuli used in discrimination learning. The kind of prior experience tested in this study was the repeated exposure of shapes that were either the same, similar, or different from those used in the discrimination task. Subjects were instructed to observe carefully but were not given an indication of any following task. The comparison of the pretraining conditions in this study resulted in the finding of no significant difference between conditions.

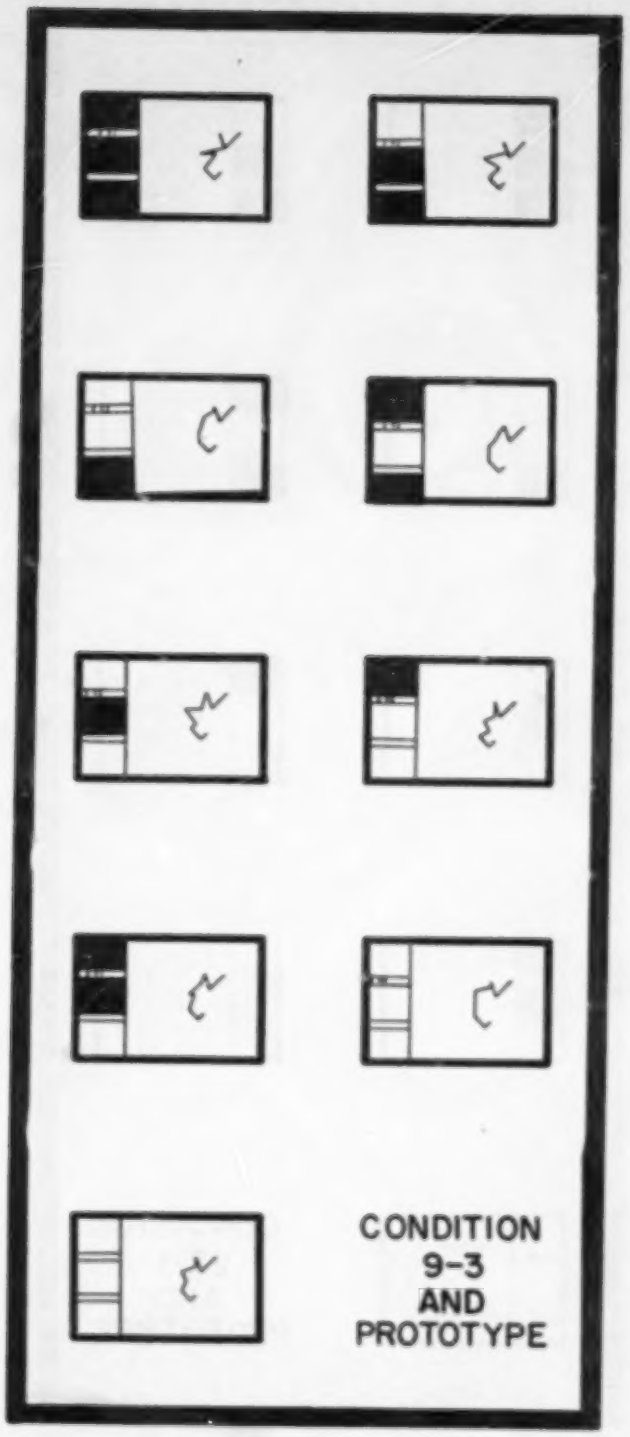
Several lines of research in the area of discrimination learning of complex shapes are suggested by the findings of this study. The findings of facilitation of discrimination learning as a function of increasing relevant and decreasing irrelevant cues should be tested on a wider sample of shapes since the findings in this study are based upon variations of one basic stimulus shape. Furthermore, an increase in the redundant irrelevant content (elements in a stimulus array that are identical from stimulus to stimulus) would allow the further description of the relationship between discrimination learning and redundant irrelevant content. Some question about the type of relationship is suggested by the finding that although the effect was linear, neither of the experiments showed a significant difference between mean errors on stimulus

figures from the two higher levels of irrelevant content. Although this study restricted its investigation to redundant irrelevant content, the effects of irrelevant content that vary independently should be investigated in the context of the tasks and stimuli sampled in the present study. The effects upon discrimination learning of including irrelevant content of various kinds over a series of previous tasks should be further studied and related to existing studies. Prior training on the irrelevant content only, by drawing the figure from memory would provide data that would be useful in interpreting the apparent conflict between the findings of Attneave (1957) and the present study. Studies of the effect of introducing additional relevant information in the same dimension but at a different location or in an independent dimension would usefully extend the present and other related findings. The wide variation in performance between subjects on all combinations of experimental conditions indicates that there are many other factors that affect the learning of discrimination tasks with pictorial stimuli that await identification and study. The incidental finding of differences in performance as a function of age suggests the possible value of exploring further the effects of prior experience or other variables that might be related to age differences.

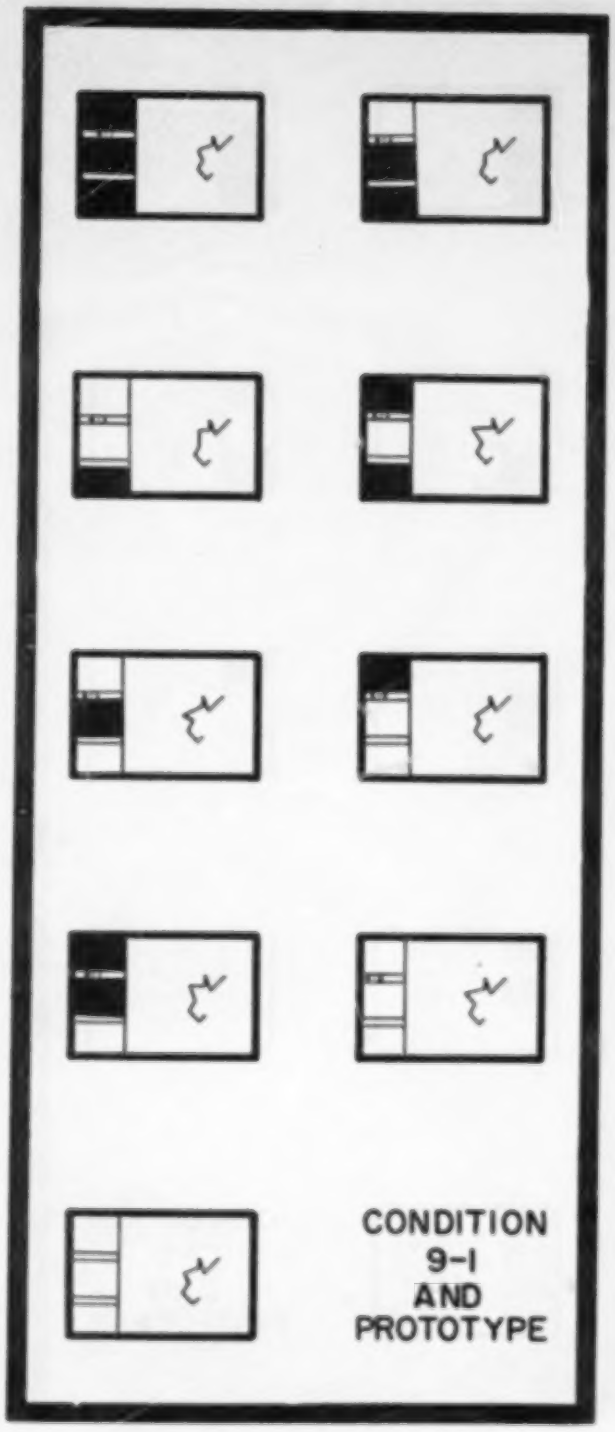




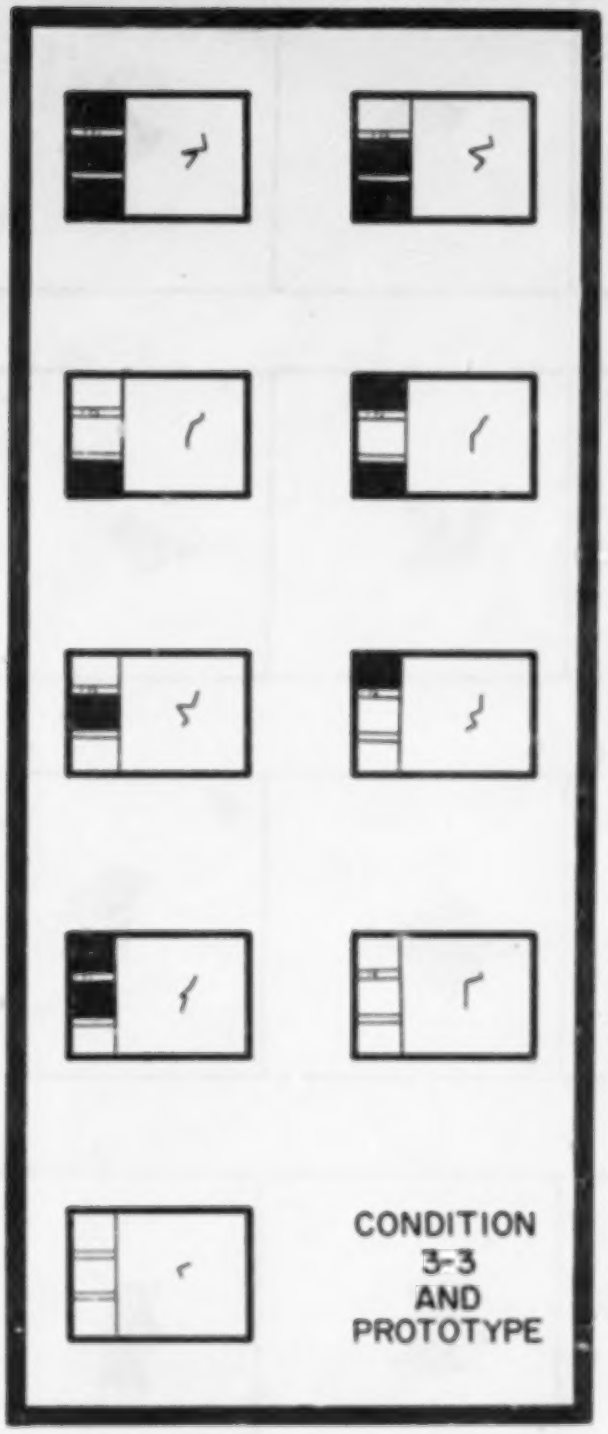
Appendix A. Stimulus Figures.

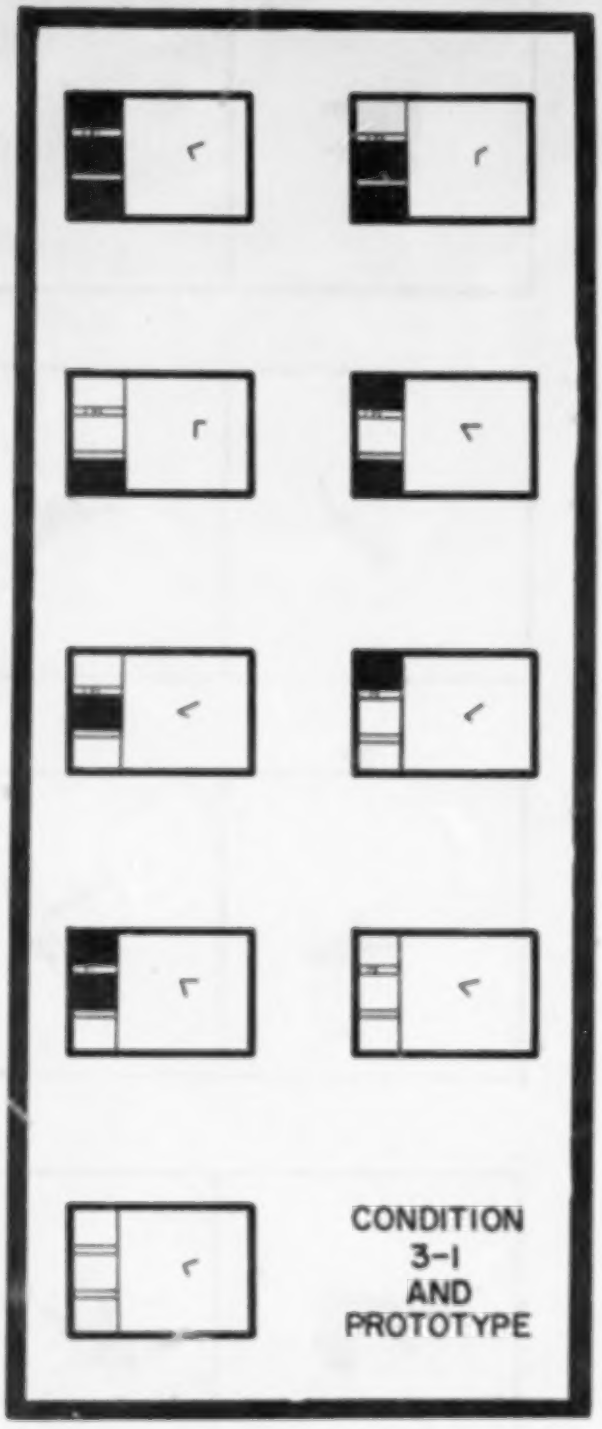


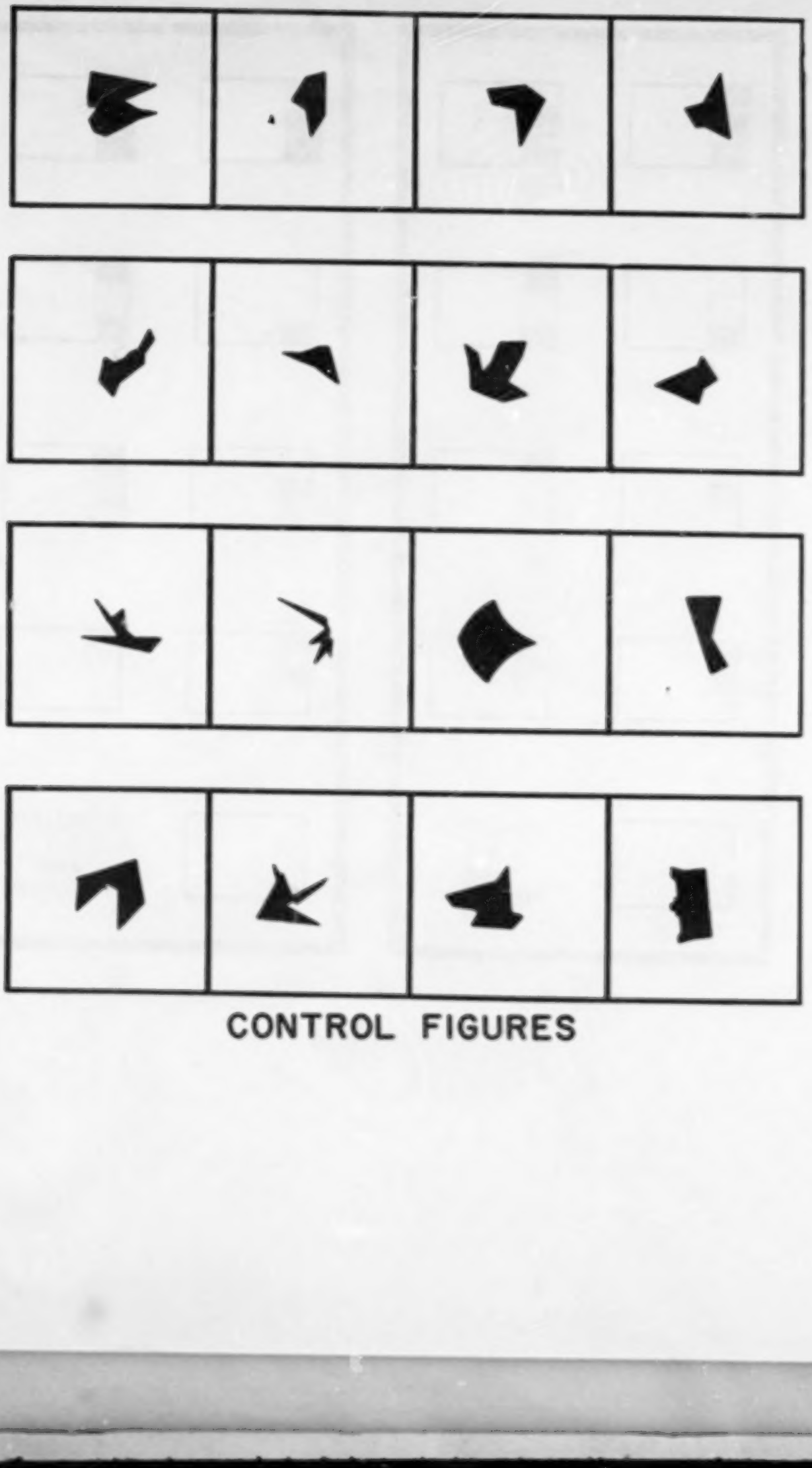
CONDITION
9-3
AND
PROTOTYPE



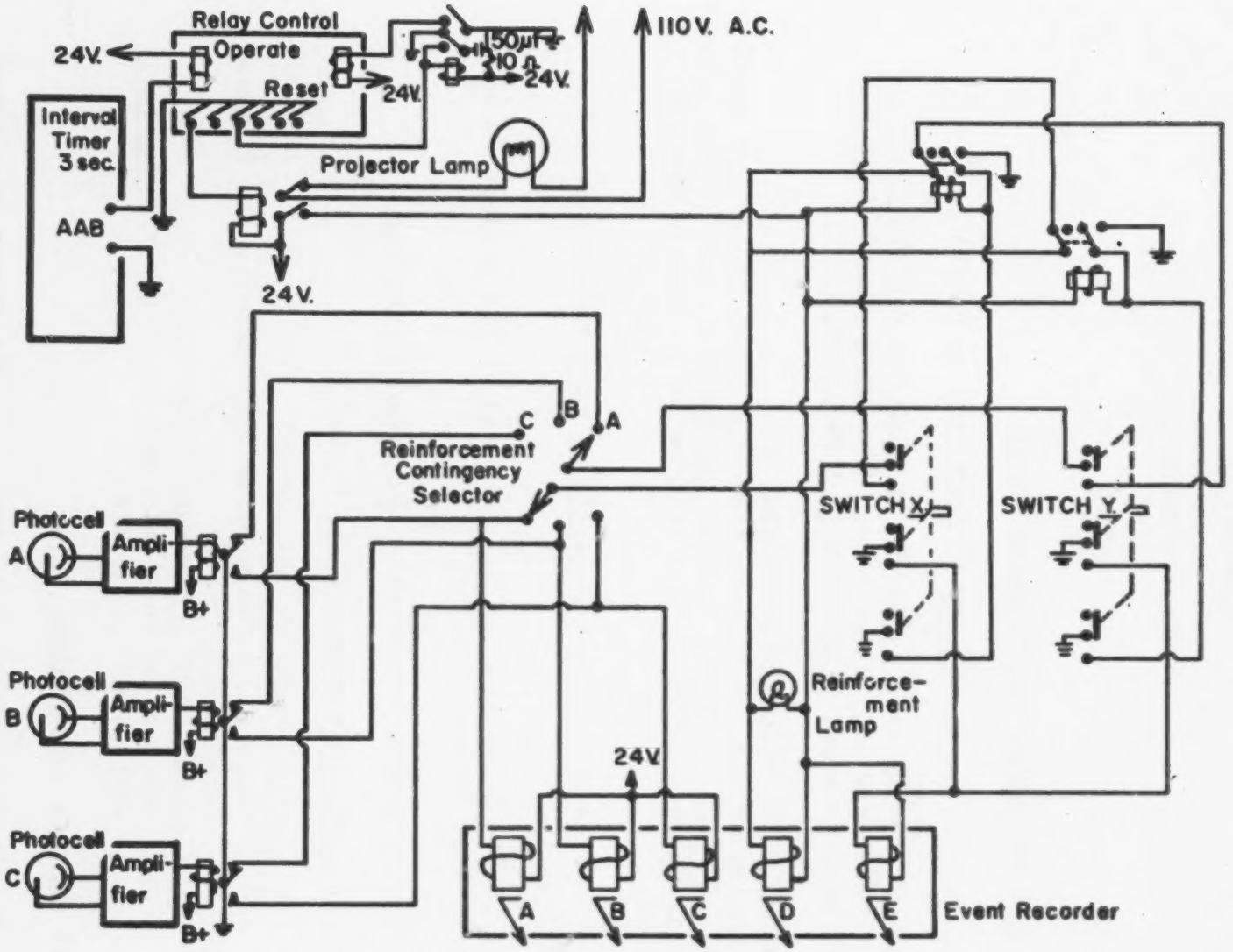
CONDITION
9-1
AND
PROTOTYPE


CONDITION
3-3
AND
PROTOTYPE


CONDITION
3-1
AND
PROTOTYPE



CONTROL FIGURES



Appendix B. Wiring Diagram

Appendix C

Instructions

PART I

(WRITE SUBJECT NUMBER ON RECORDING TAPE)

Hello.....I am Mr. Black (RECORD NAME ON "LOG")

Please come in here. (ESCORT TO RESPONSE POSITION.)
Put your coat and things here. (ON CHAIR BEHIND SUBJECT.)
YOU may sit here. (IN CHAIR AT S POSITION.)

(AFTER S IS IN CHAIR COMFORTABLY.)
A series of figures will be projected onto this screen (INDICATE SCREEN). YOU are to look carefully at the figures projected on the screen. The figures will be projected a number of times.

Your only task is to look carefully each time a figure is projected.

Try not to be distracted by the sound of the projection equipment as it is rather noisy.

Your only task is to observe the figures carefully.

Do you understand what you are to do?.....

(if asked, "WHAT IS PURPOSE"???
respond.....The purpose is to observe the figures
1 minute carefully.)
(if asked, "MUST I REMEMBER FIGURES"???
respond.....Your only task is to observe carefully each figure projected.....)

(IF SUBJECT UNDERSTANDS.....)

Good, the first figure will appear on the screen in a moment.
Excuse me please.....
(CHECK TO SEE IF RIGHT SLIDE DRUM IS IN)

14.4 minutes

(PULL OUT PLUG AFTER LAST SLIDE.)

That is the end of the first task....You may take a minute to relax.
(SET PANEL FOR 1ST SLIDE.)

PART II

(CHECK SLIDE CARRIAGE FOR SERIES)

(AFTER 1 MINUTE)

Now you will have a new task. You will learn which of these two switches (POINT TO SWITCH) in front of you to push (INDICATE HOW TO PUSH) in order to turn on this light (INDICATE REINFORCEMENT LIGHT) above the screen.

The left switch will turn on the light only when certain figures are on the screen and the right switch turns on the light only when the other figures are shown.

One and only one of the switches turns on the light for each figure. You will learn which switch turns on the light for a given figure by pushing one of the two switches when the figure is still on the screen.

If the light (INDICATE) goes on you will try to remember the figure and the switch you pushed so you can remember how to turn on the light the next time that same figure is presented.

If you push a switch and the light does not go on it means that the other switch turns on the light.

You will get to make only one response while the figure is on the screen. If you should make more than one response the second responses will not turn on the light regardless of which switch you push.

Only the first response made while a figure is on the screen tells you which switch will turn on the light for that figure.

The difference between some of the figures may seem slight at first, but you will soon be able to tell which figures are associated with the left switch and which with the right.

Even though you may not be sure whether to press the left or right switch, it is important to push one of the switches each time a figure is shown.

As each figure appears on the screen you are to decide which switch to press as soon as you can after it appears.

The object is to learn which switch is correct for each figure. Any time you push a switch and the light does not turn on, study the figure so you will remember which switch to press the next time you see it.

There is no special rule or shortcut that will tell you how to get the light to turn on each time. The only sure way to learn how to turn on the light each time is to learn to tell the figures apart and remember which switch turns on the light for each figure.

Do you understand what you are to do?????

(TRIAL RUN)

Let's try with one figure.....(HAVE PROJECTOR SET ON FIRST SLIDE IN SEQUENCE)

When the figure appears push one of the switches. (If incorrect...the same figure will appear again.....(BE SURE HE ONLY MAKES ONE RESPONSE PER FRAME) Leave on until S makes one correct response. Then start next slide in sequence..... (HAVE SUBJECT SEE THAT ONE POSITION TURNS ON THE LIGHT AND THE OTHER DOESN'T).....The next figure will appear in a moment.

(RUN TWELVE - 12 - CYCLES).....14.4 minutes.....(PULL PLUG)

We'll take a short break now
(RECORD ON TAPE WHEN BREAK OCCURRED)

(AFTER ONE MINUTE)

(1st SLIDE)

(RUN 12 CYCLES)
14.4 minutes
(PULL PLUG)

That is the end of the session. Thank you for your cooperation. Here is your dollar for your participation in the experiment (GIVE SUBJECT $1.00)

In order to make the task of equal difficulty for those following you, please do not discuss the details of the experiment with other persons at University High School who have not yet participated.

Any Questions?????

(IF TIME ALLOWS, INVITE SUBJECT TO SEE EXPERIMENTAL EQUIPMENT...ANSWER QUESTIONS)

(RECORD NAME--EXPERIMENT NUMBERS ON)

1. TAPE
2. LOG
3. ROSTER

Appendix D

Error Scores on Discrimination Task* (Experiment I)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)		Sum of errors Trials 2–24
(P)	(I)	(R)	Rep	Rei	GL	S			
P	27	1	A	C	12	f	4 6 2 1 1 1 3 2 0 0 0 1	1 0 0 1 1 0 0 0 0 0 0 0	20
P	27	1	B	A	10	m	5 3 2 3 4 2 5 2 2 2 4 3	3 1 3 4 2 1 2 0 0 1 3 2	54
P	27	1	C	C	11	m	2 3 2 3 5 4 2 2 1 2 4 3	4 3 3 1 2 2 1 2 3 1 2 1	56
P	27	1	D	A	10	m	4 5 5 2 2 3 4 0 3 3 3 2	1 0 1 2 2 1 1 0 1 4 0 0	45
									175
P	27	3	A	A	11	f	2 1 0 1 0 1 0 4 2 4 2 2	2 1 2 0 0 0 0 1 1 0 0 0	24
P	27	3	B	C	10	f	5 3 3 3 3 4 1 1 0 2 1 4	0 2 1 5 1 2 0 2 0 2 1 1	42
P	27	3	C	A	11	f	4 5 2 3 1 1 2 1 1 2 0 1	2 1 2 2 0 1 1 1 0 1 0 1	31
P	27	3	D	C	11	m	5 6 4 3 4 3 5 1 4 4 0 1	1 2 2 2 2 1 2 2 1 1 2 4	57
									154
									329
P	9	1	A	C	10	f	3 6 2 3 7 3 2 3 3 1 2 3	3 2 2 3 3 2 2 2 2 1 1 2	60
P	9	1	B	A	10	f	5 4 3 4 3 4 3 2 1 1 2 0	1 1 0 0 0 0 0 0 1 1 0 0	31
P	9	1	C	C	11	f	6 4 2 3 5 6 4 3 6 4 3 4	5 3 1 2 2 2 1 1 1 0 0 1	63
P	9	1	D	A	12	f	5 2 4 4 3 3 2 3 1 3 4 2	2 2 4 3 2 0 3 3 3 2 4 3	62
									216

(P) = pretraining; (I) = irrelevant; (R) = relevant; Rep = replication; Rei = Reinforcement; GL = grade level; S = sex.

(Experiment I)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)		Sum of errors	
(P)	(I)	(R)	Rep	Rei	GL	S			Trials 2-24	
P	9	3	A	C	11	m	4 2 6 7 4 3 2 0 3 5 5 3	4 3 3 1 1 0 1 1 1 1 0 0	56	
P	9	3	B	A	10	m	4 3 1 4 0 4 0 2 4 0 1 3	1 1 0 1 0 1 0 0 0 0 0 0	26	
P	9	3	C	C	11	f	6 2 3 0 1 2 2 1 3 0 1 1	2 1 1 1 2 0 0 1 0 1 1 1	27	
P	9	3	D	A	11	m	4 5 5 4 1 1 2 1 2 0 1 1	1 0 0 0 0 0 0 0 0 0 0 0	24	
									133	
									349	
P	3	1	A	C	11	m	5 3 0 2 2 0 1 2 0 1 1 1	0 0 0 0 0 0 0 0 0 0 0 0	13	
P	3	1	B	A	12	f	3 4 5 5 2 4 4 3 2 4 3 2	1 2 2 1 1 1 2 1 2 0 3 1	55	
P	3	1	C	C	12	f	4 4 4 1 3 4 4 4 0 2 1 1	0 1 1 1 0 0 0 0 0 0 0 0	31	
P	3	1	D	A	11	m	4 4 4 3 2 1 2 1 3 0 0 0	1 0 2 0 0 0 0 0 1 0 0 0	24	
									123	
P	3	3	A	C	10	m	4 4 1 1 1 0 2 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0 0	10	
P	3	3	B	A	12	m	4 4 3 5 3 1 1 1 2 1 1 0	1 0 0 0 0 0 0 0 0 0 0 0	23	
P	3	3	C	C	12	m	6 7 1 5 1 1 2 1 2 3 1 0	2 1 0 0 1 0 1 1 1 1 1 0	33	
P	3	3	D	A	10	m	3 3 2 3 3 4 4 3 2 4 3 4	2 3 2 2 4 3 4 4 0 3 1 0	67	
									133	
									256	
										934

(Experiment I)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)		Sum of errors Trials 2-24
(P)	(I)	(R)	Rep	Rei	GL	S			
C	27	1	A	A	11	m	2 1 2 5 2 3 1 6 4 3 1 1	3 3 2 3 3 1 3 4 3 3 2 3	62
C	27	1	B	C	12	f	2 5 4 3 5 3 3 1 4 1 1 4	4 2 1 2 3 3 1 2 5 1 4 3	65
C	27	1	C	A	12	f	6 4 2 3 4 2 3 4 3 4 3 4	1 3 1 4 1 1 3 1 2 1 0 0	54
C	27	1	D	C	12	m	4 3 4 6 4 7 3 3 2 5 4 3	3 4 2 1 2 1 2 2 1 1 2 1	66
									247
C	27	3	A	A	10	f	2 2 0 2 2 2 1 2 1 1 0 3	1 0 1 0 1 0 0 1 1 1 1 0	23
C	27	3	B	C	11	f	2 5 3 3 3 4 4 4 2 1 0 1	0 1 0 0 0 0 0 0 0 0 0 0	31
C	27	3	C	A	12	f	5 4 0 3 1 0 1 0 0 0 1 0	0 0 0 0 0 0 0 0 0 0 0 1	11
C	27	3	D	C	11	f	8 2 2 4 1 0 0 0 1 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0	10
									75
C	9	1	A	A	12	f	3 6 5 3 6 4 4 4 2 3 2 3	3 4 2 0 3 2 0 0 0 0 1 1	57
C	9	1	B	C	12	m	3 4 1 5 5 3 4 1 3 3 1 3	2 2 2 2 3 2 0 1 1 1 1 1	51
C	9	1	C	A	12	m	3 5 2 4 6 4 2 5 2 3 2 2	4 2 1 5 3 1 4 2 4 2 5 1	71
C	9	1	D	C	11	f	4 6 3 5 3 4 4 4 4 4 2 4	4 2 2 4 2 2 0 2 2 2 1 2	68
									247
C	9	3	A	A	12	m	6 6 2 1 1 1 2 1 0 1 1 0	0 1 0 2 0 0 0 0 0 0 0 0	19
C	9	3	B	C	11	m	5 2 2 0 1 0 1 0 1 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0	7
C	9	3	C	A	12	m	7 3 0 2 3 6 3 2 4 1 2 3	3 4 2 2 1 2 2 2 1 2 2 1	53
C	9	3	D	C	11	f	5 2 7 4 4 1 4 4 4 7 3 3	4 3 5 4 3 4 4 5 1 2 3 3	79
									158

(Experiment I)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)		Sum of errors	
(P)	(I)	(R)	Rep	Rei	GL	S			Trials 2-24	
C	3	1	A	C	11	f	2 2 3 2 2 2 2 1 2 1 3 2	2 1 1 1 2 1 0 0 1 2 1 1	35	
C	3	1	B	A	11	m	4 2 1 3 3 3 3 4 4 3 2 2	2 2 4 1 1 1 0 0 2 0 0 0	43	
C	3	1	C	C	11	f	3 4 1 4 3 2 1 1 3 4 1 1	3 1 2 4 2 2 3 2 1 1 1 2	59	
C	3	1	D	A	11	m	1 2 3 3 1 2 1 2 0 0 1 0	0 2 0 0 0 1 0 1 0 1 1 0	21	
									158	
C	3	3	A	C	11	f	3 5 2 6 5 0 0 0 0 0 0 1	0 0 0 0 0 0 0 0 0 0 1 0	20	
C	3	3	B	A	10	f	3 2 4 4 1 2 2 3 4 3 3 1	3 5 2 2 1 2 2 1 3 0 1 0	51	
C	3	3	C	C	11	m	5 3 3 1 2 4 1 1 2 0 0 1	1 0 0 0 0 0 0 0 0 0 1 0	19	
C	3	3	D	A	11	f	3 5 5 3 3 2 2 4 3 3 1 0	5 3 4 2 2 1 0 1 1 2 1 0	53	
									143	
									1,028	
8	27	1	A	C	10	f	2 4 3 5 3 5 4 1 3 3 2 0	2 2 3 2 0 1 2 2 1 0 0 2	50	
8	27	1	B	C	10	m	4 7 3 2 4 4 6 1 4 4 2 2	2 1 2 2 1 0 0 1 1 0 0 1	50	
8	27	1	C	A	11	m	4 4 3 3 5 3 3 2 2 2 2 1	1 2 1 1 2 1 0 0 1 1 0 0	40	
8	27	1	D	A	12	m	5 2 3 3 2 4 4 5 4 5 3 4	5 3 4 4 2 3 1 4 5 3 5 2	80	
									220	
8	27	3	A	A	11	m	5 2 4 4 3 1 1 3 0 1 0 0	0 0 0 0 0 0 0 0 0 0 0 0	20	
8	27	3	B	C	11	m	3 4 3 2 2 3 4 2 0 4 3 2	3 1 1 2 3 1 2 1 2 0 1 0	46	
8	27	3	C	A	12	f	4 2 2 4 4 2 2 3 1 3 2 1	1 0 1 1 0 0 0 0 1 0 0 0	31	
8	27	3	D	C	11	m	4 4 2 2 3 5 2 2 4 3 3 2	3 4 3 1 6 4 2 2 3 4 4 3	71	
									168	

(Experiment I)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)		Sum of errors	
(P)	(I)	(R)	Rep	Rei	GL	S			Trials 2-24	
8	9	1	A	C	10	f	2 3 4 4 3 4 3 4 1 4 3 1	2 1 3 0 2 0 1 2 1 0 3 1	50	
8	9	1	B	A	11	m	2 4 3 5 5 2 2 1 3 2 2 1	2 1 0 1 2 1 1 1 3 2 0 1	45	
8	9	1	C	C	11	f	4 3 3 3 4 2 2 2 1 1 3 5	1 2 3 4 1 1 3 3 2 0 1 2	52	
8	9	1	D	A	10	f	3 3 3 1 3 2 3 1 2 3 3 3	2 3 3 1 1 3 2 2 3 2 2 1	52	
									199	
8	9	3	A	A	12	m	5 3 3 3 6 3 0 1 1 2 1 0	2 0 1 0 0 0 0 5 0 0 0 1	32	
8	9	3	B	C	10	f	7 4 3 5 3 4 5 4 2 3 4 2	3 4 2 5 2 2 2 3 2 2 2 2	70	
8	9	3	C	A	11	m	4 3 2 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 1 0	6	
8	9	3	D	C	11	m	7 4 3 3 3 2 0 1 0 2 0 3	2 1 0 0 0 0 1 0 0 0 1 2	28	
									136	
8	3	1	A	A	12	m	2 3 1 6 1 2 2 2 2 6 3 0	2 1 1 1 2 1 2 2 2 3 0 3	48	
8	3	1	B	A	10	m	4 4 1 3 1 1 3 2 4 2 1 2	3 2 2 2 1 3 2 2 2 2 0 1	46	
8	3	1	C	C	11	f	0 5 4 3 4 4 3 1 1 1 2 0	1 0 0 1 0 0 1 2 0 1 0 0	33	
8	3	1	D	C	11	f	4 3 2 4 6 2 5 2 2 3 3 1	3 4 1 2 2 0 2 3 1 0 1 0	43	
									180	
8	3	3	A	A	11	m	3 5 2 2 1 4 2 1 1 1 0 0	0 1 0 0 0 0 1 0 0 0 0 0	21	
8	3	3	B	C	11	m	3 0 0 0 0 0 0 0 0 0 0 0	0 1 0 0 0 0 0 0 0 0 0 1	2	
8	3	3	C	A	12	f	5 4 3 3 3 3 5 2 1 3 4 3	3 4 3 0 0 1 1 2 1 1 2 2	54	
8	3	3	D	C	10	f	3 5 1 1 1 2 0 0 0 0 0 1	0 0 0 0 0 0 0 0 0 0 0 0	11	
									88	
									991	

(Experiment I)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)		Sum of errors	
(P)	(I)	(R)	Rep	Rei	GL	S			Trials 2–24	
4	27	1	A	A	11	m	3 4 1 5 6 1 2 3 3 2 1 5	1 1 2 4 5 0 2 4 4 1 1 5	64	
4	27	1	B	C	10	f	6 2 3 0 3 3 2 3 2 2 3 2	1 1 2 1 0 2 0 1 1 0 2 1	37	
4	27	1	C	A	11	f	3 2 2 2 3 4 4 2 3 3 4 4	2 3 4 2 4 2 3 4 3 4 5 3	72	
4	27	1	D	C	11	m	6 3 3 1 4 3 3 5 4 4 2 3	2 1 1 1 2 1 0 0 0 0 0 0	43	
									216	
4	27	3	A	C	10	f	3 3 3 0 0 1 0 1 0 0 2 0	1 0 0 1 0 0 0 0 0 1 1 0	14	72
4	27	3	B	A	11	f	2 4 3 3 3 4 5 3 4 1 0 2	0 2 2 2 1 0 1 1 0 0 0 0	41	
4	27	3	C	C	11	m	5 3 2 2 0 0 0 2 2 3 2 3	0 3 0 1 1 1 0 0 0 1 1 1	28	
4	27	3	D	A	12	m	5 4 4 2 2 1 4 1 2 2 2 1	2 1 0 0 2 1 0 0 0 0 0 0	31	
									114	
4	9	1	A	A	10	f	2 5 3 3 2 5 2 1 4 1 1 2	1 0 0 4 4 1 1 2 0 4 2 1	49	
4	9	1	B	C	11	f	6 4 4 4 5 1 3 2 2 2 2 1	1 1 0 2 2 1 1 2 1 0 0 1	42	
4	9	1	C	A	12	m	3 2 3 2 1 1 3 1 1 0 2 1	1 2 1 0 1 0 0 1 0 2 1 2	28	
4	9	1	D	C	10	m	3 5 5 7 6 5 3 4 3 5 3 5	1 4 3 5 2 5 3 4 5 5 4 6	98	
									217	
4	9	3	A	C	10	f	4 3 3 1 3 1 2 3 2 1 1 2	0 0 1 1 1 1 0 1 1 0 1 0	29	
4	9	3	B	A	10	f	3 1 4 5 3 5 3 4 3 5 3 4	1 2 1 3 1 2 0 0 0 0 0 0	50	
4	9	3	C	C	10	f	5 5 5 4 3 3 1 2 0 1 2 1	2 2 3 1 0 0 0 1 0 0 0 0	36	
4	9	3	D	A	12	m	2 5 2 4 2 0 1 0 1 1 0 0	1 1 0 1 0 0 0 0 0 0 0 0	19	
									134	

(Experiment I)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)		Sum of errors Trials 2-24
(P)	(I)	(R)	Rep	Rei	GL	S			
4	3	1	A	A	11	m	5 1 3 3 3 2 2 1 2 2 0 0	1 0 1 0 1 0 0 0 0 1 0 0	23
4	3	1	B	C	11	m	5 1 5 2 3 2 4 2 4 1 2 3	2 3 2 3 2 1 2 0 2 1 2 2	52
4	3	1	C	A	10	m	3 2 3 2 2 2 2 3 0 0 0 2	2 0 0 0 0 0 0 2 1 0 0 0	23
4	3	1	D	C	10	f	6 3 2 2 2 1 2 2 1 1 1 0	2 2 1 0 0 0 1 1 0 0 1 0	25
									123
4	3	3	A	A	10	f	5 2 3 1 2 3 3 2 2 3 4 2	1 2 1 1 3 1 1 1 0 0 0 0	37
4	3	3	B	C	12	m	2 6 4 5 4 2 4 0 2 0 1 0	3 2 1 1 1 0 1 0 1 0 1 0	39
4	3	3	C	A	10	f	5 3 2 1 2 1 0 1 1 1 1 0	0 0 0 0 0 0 0 0 0 0 0 0	13
4	3	3	C	C	12	m	4 4 2 2 2 3 1 0 2 1 1 1	0 3 1 1 0 0 0 0 2 1 0 0	27
									116
									920
2	27	1	A	C	12	m	5 3 4 5 1 2 3 3 5 1 3 2	1 3 1 0 1 0 0 1 0 0 1 1	41
2	27	1	B	A	10	f	4 3 2 5 3 4 2 3 4 3 1 4	3 2 3 3 2 6 3 3 4 2 1 5	71
2	27	1	C	C	10	f	3 2 4 2 4 4 3 3 4 2 3 1	2 1 2 1 0 1 0 2 1 1 0 0	43
2	27	1	D	A	10	f	4 4 3 2 5 6 3 5 4 6 3 3	4 4 1 2 1 1 2 3 2 2 0 2	68
									223
2	27	3	A	C	11	f	4 2 0 2 3 4 1 0 1 1 1 0	2 0 0 0 0 0 0 0 0 0 0 0	17
2	27	3	B	A	10	m	5 3 1 6 3 4 3 5 3 3 3 2	3 1 0 4 2 2 2 2 2 1 1 1	57
2	27	3	C	C	10	m	1 3 5 5 6 5 3 0 1 1 1 0	0 0 0 1 1 0 0 0 0 0 0 0	32
2	27	3	D	A	10	f	6 3 4 3 3 1 4 2 4 3 2 1	0 0 1 1 0 0 0 2 2 1 0 0	37
									143

(Experiment I)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)	Sum of errors: Trials 2-24
(P)	(I)	(R)	Rep	Rei	GL	S		
2	9	1	A	C	10	f	6 4 2 1 1 3 2 1 1 3 2 1 4 0 0 0 1 1 1 0 0 1 1 0	30
2	9	1	B	A	10	m	4 1 1 0 4 3 3 2 4 2 1 4 4 2 2 1 3 1 2 0 2 2 0 5	49
2	9	1	C	C	12	m	3 3 1 1 5 4 3 4 3 2 2 2 0 1 1 0 0 0 1 0 0 1 0 0	34
2	9	1	D	A	11	f	6 1 3 2 2 3 2 2 1 3 1 0 2 0 1 0 0 1 0 2 0 0 0 4	30
								143
2	9	3	A	C	11	f	4 3 4 2 2 3 4 3 2 3 3 4 3 2 3 3 3 1 4 3 1 0 0 2	25
2	9	3	B	A	10	f	4 4 3 3 3 3 2 2 4 4 2 2 3 2 1 2 1 1 1 1 2 1 1 2	50
2	9	3	C	A	12	f	3 1 1 1 0 1 0 2 0 1 1 3 0 0 0 0 0 0 0 0 0 0 0 0	11
2	9	3	D	C	10	f	5 5 4 2 5 4 1 1 0 2 0 0 2 1 0 0 2 0 0 1 2 0 0 0	32
								118
2	3	1	A	C	12	f	2 4 4 4 4 4 1 4 5 2 3 2 1 2 2 2 3 3 2 2 1 2 2 1	60
2	3	1	B	A	11	m	3 3 2 3 2 2 2 0 2 1 1 0 0 0 2 0 0 2 0 0 0 0 0 0	22
2	3	1	C	C	12	m	4 1 1 2 0 1 0 1 2 2 1 0 0 1 0 0 1 0 0 0 1 1 1	16
2	3	1	D	A	10	m	8 5 3 6 3 4 5 1 2 5 4 5 5 2 4 3 0 3 3 4 2 2 3 3	77
								175
2	3	3	A	A	12	f	4 4 4 3 5 4 3 2 3 1 4 4 2 2 2 0 0 0 2 1 0 2 0 0	48
2	3	3	B	C	11	f	5 1 4 3 1 3 1 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0	16
2	3	3	C	A	11	f	4 2 1 0 2 3 3 1 2 0 1 0 3 0 0 0 0 0 0 0 0 0 1 0	19
2	3	3	D	C	10	f	4 1 2 5 3 2 2 2 1 2 2 0 1 1 0 0 0 0 0 1 0 0 0	25
								108
								910

(Experiment II)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)	Sum of errors	
(P)	(I)	(R)	Rep	Rei	GL	S		Trials 2–24	
P	27	1	A	C	9	f	5 4 4 5 4 7 3 3 3 3 3 4 3 3 3 1 3 2 1 1 4 3 0 1	65	
P	27	1	B	A	9	f	2 1 2 3 3 2 2 2 3 2 1 2 4 2 4 3 3 1 3 3 2 2 3 3	56	
P	27	1	C	C	9	f	5 4 6 1 5 5 3 7 5 6 3 3 5 3 3 1 3 3 5 2 4 3 3 3	86	
P	27	1	D	A	9	m	4 6 5 6 6 5 3 4 5 4 3 2 3 3 0 3 2 2 1 1 1 3 1 0	69	
									276
P	27	3	A	A	9	m	6 1 3 1 2 3 1 1 0 0 0 0 2 0 0 1 0 0 0 1 0 1 0 0	17	
P	27	3	B	C	9	f	7 5 3 3 4 3 4 1 5 4 3 4 4 3 2 3 3 1 1 1 1 1 1 2	61	
P	27	3	C	A	9	f	7 7 3 4 5 5 5 4 7 5 0 2 5 6 2 4 1 4 3 5 3 5 7 5	97	
P	27	3	D	C	9	m	7 4 2 3 5 2 4 6 2 3 5 3 4 2 3 4 3 0 0 0 0 0 0 1	56	
									231
									507
P	9	1	A	A	9	f	5 3 5 3 6 2 2 3 2 3 2 2 2 2 2 2 3 1 1 1 2 1	54	
P	9	1	B	C	9	f	4 5 2 1 4 2 3 2 1 1 4 4 1 1 0 2 1 1 1 1 1 1 1 0	40	
P	9	1	C	A	9	m	5 5 1 4 3 4 5 3 5 5 1 3 4 3 4 1 1 2 2 0 1 1 1 0	59	
P	9	1	D	C	9	f	5 2 3 4 2 5 4 1 0 5 4 3 4 2 1 4 2 4 2 3 1 1 4 3	66	
									219
P	9	3	A	A	9	m	5 4 4 6 5 4 3 2 4 3 2 4 4 2 1 1 2 3 3 1 0 1 2 4	69	
P	9	3	B	C	9	f	5 5 5 4 3 4 1 3 1 4 3 4 3 1 2 4 3 4 2 2 2 3 3 3	69	
P	9	3	C	A	9	m	4 4 5 4 2 2 4 3 1 3 2 0 3 1 2 2 2 0 1 1 1 2 0 0	45	
P	9	3	D	C	9	f	4 3 3 1 5 2 3 2 1 2 2 0 0 1 0 0 0 0 0 0 1 0 0 0	26	
									209
									428

(Experiment II)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)		Sum of errors
(P)	(I)	(R)	Rep	Rei	GL	S			Trials 2-24
P	3	1	A	C	9	m	5 3 3 1 2 3 4 0 0 0 4 3	2 2 1 1 2 1 1 2 1 3 3 0	42
P	3	1	B	C	9	f	3 2 4 5 4 3 3 4 2 2 2 1	3 4 0 2 2 0 1 2 2 0 2 1	51
P	3	1	C	C	9	m	2 1 2 1 3 2 3 3 2 2 0 2	1 1 2 1 1 1 2 2 0 1 2 2	37
P	3	1	D	A	9	f	3 2 1 2 1 1 1 0 2 2 0 0	0 0 0 0 1 2 1 0 1 0 0 1	18
									148
P	3	3	A	A	9	m	5 4 4 5 1 1 5 3 3 2 0 2	3 1 1 1 1 0 0 1 1 0 2 0	41
P	3	3	B	A	9	m	2 3 2 3 1 0 2 0 1 1 1 0	1 0 0 1 0 0 0 0 0 1 0 0	17
P	3	3	C	A	9	m	5 4 3 2 3 2 1 1 1 1 0 0	0 0 0 0 0 0 0 0 0 0 1 0	19
P	3	3	C	C	9	f	4 4 1 4 2 2 2 4 1 1 3 2	2 2 3 1 2 3 1 0 1 0 1 0	43
									120
									268
									1,203
C	27	1	A	C	9	m	6 4 4 3 3 3 4 3 3 4 3 3	2 4 1 2 1 1 0 1 2 0 1 1	53
C	27	1	B	A	9	m	4 2 3 2 4 3 3 3 4 2 2 5	5 4 1 3 0 3 6 4 3 4 1 4	72
C	27	1	C	C	9	m	7 4 5 4 4 3 4 4 5 2 1 1	3 0 1 0 1 4 1 3 1 0 1 0	52
C	27	1	D	A	9	m	4 4 3 3 2 3 2 0 1 2 2 3	3 1 3 1 2 2 2 1 3 4 3 2	52
									229
C	27	3	A	A	9	m	2 5 4 3 4 5 5 0 2 4 0 1	2 3 3 2 1 2 2 5 2 5 2 3	65
C	27	3	B	C	9	m	3 4 1 1 2 1 0 0 1 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0	10
C	27	3	C	A	9	f	7 5 2 4 4 1 2 2 0 3 3 3	2 1 0 1 1 0 2 0 1 0 0 0	37
C	27	3	D	C	9	f	5 5 3 3 3 4 1 3 2 2 6 1	2 1 0 0 0 0 0 1 0 0 0 0	37
									149
									378

(Experiment II)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)		Sum of errors	
(P)	(I)	(R)	Rep	Rei	GL	S			Trials 2-24	
C	9	1	A	A	9	m	5 3 3 4 4 5 2 3 4 2 1 2	3 3 1 4 2 3 1 3 2 1 0 0	56	
C	9	1	B	C	9	m	3 5 2 3 5 5 3 1 3 4 4 5	3 4 2 2 4 3 4 3 5 3 0 2	75	
C	9	1	C	A	9	m	2 2 5 5 6 3 6 4 4 3 5 6	5 4 4 2 2 4 7 6 4 3 7 3	100	
C	9	1	D	C	9	f	4 3 3 5 5 6 4 4 3 3 6 5	4 3 2 4 2 6 2 3 2 5 6 4	90	
										321
C	9	3	A	C	9	m	5 5 3 7 3 3 5 6 5 4 3 2	1 3 1 2 2 1 1 1 1 3 1 0	63	
C	9	3	B	A	9	f	6 2 1 1 1 2 1 0 0 1 0 1	0 0 0 0 0 0 0 0 0 0 0 2	12	
C	9	3	C	C	9	m	5 2 2 4 4 5 5 3 2 2 3 2	1 3 1 1 1 1 1 1 1 0 0 0	45	
C	9	3	D	A	9	f	4 2 2 3 4 1 3 4 1 1 1 5	2 1 2 0 1 0 1 0 0 1 2 0	37	
										157
										478
C	3	1	A	C	9	m	5 4 2 5 4 3 3 5 4 1 4 4	1 4 4 3 2 3 2 0 2 2 0 3	65	
C	3	1	B	A	9	m	4 3 1 3 3 3 2 3 3 2 2 3	5 0 2 3 1 1 2 2 2 2 0 1	49	
C	3	1	C	C	9	m	5 2 2 0 0 0 2 1 1 1 2 1	0 1 0 0 1 0 0 0 0 0 0 0	14	
C	3	1	D	A	9	f	5 5 5 6 1 5 1 2 4 1 1 2	3 1 2 0 1 2 3 4 2 0 1 3	55	
										183
C	3	3	A	A	9	m	4 4 2 3 3 1 2 0 0 2 0 1	0 1 0 0 0 0 0 0 0 0 0 0	19	
C	3	3	B	C	9	m	5 3 4 2 3 1 1 1 1 0 0 0	0 2 1 0 0 0 0 0 0 0 1 0	20	
C	3	3	C	A	9	m	4 3 4 4 3 4 5 2 1 4 4 1	0 1 4 1 1 1 1 1 2 0 0 1	48	
C	3	3	D	C	9	f	5 3 4 4 2 2 2 4 2 2 3 1	1 2 2 1 2 2 1 1 0 1 1 1	44	
										131
										314
										1,170

(Experiment II)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)		Sum of errors Trials 2-24
(P)	(I)	(R)	Rep	Rei	GL	S			
8	27	1	A	C	9	f	5 3 4 8 3 4 3 3 3 4 3 3	3 2 3 1 2 2 3 2 4 3 2 2	70
8	27	1	B	A	9	m	4 3 2 2 2 2 4 2 4 3 3 2	1 1 1 2 2 1 2 2 1 2 1 1	46
8	27	1	C	C	9	f	4 2 5 4 2 4 2 3 2 2 2 3	2 3 1 4 3 1 2 4 0 3 3 0	57
8	27	1	D	A	9	m	3 5 3 5 2 3 3 3 2 4 5 5	2 4 3 2 3 1 3 3 3 2 2 1	69
									242
8	27	3	A	A	9	f	4 5 4 1 3 2 3 5 2 1 2 1	2 2 4 3 5 5 3 2 4 5 1 4	69
8	27	3	B	C	9	f	3 4 4 3 2 1 1 1 2 1 3 0	0 0 1 0 0 0 0 1 1 0 1 1	27
8	27	3	C	A	9	f	5 6 3 2 4 4 3 1 1 2 2 2	1 1 1 2 1 1 1 0 2 0 0 0	40
8	27	3	D	C	9	f	5 2 2 2 3 2 2 5 6 3 4 5	3 3 4 3 3 5 5 2 3 3 4 3	77
									213
									455
8	9	1	A	A	9	f	4 2 5 2 1 3 2 3 1 1 0 2	3 0 2 0 2 1 2 0 0 0 0 0	30
8	9	1	B	C	9	f	3 4 3 1 6 2 2 1 3 4 3 4	4 5 2 4 6 6 5 3 4 3 3 5	83
8	9	1	C	A	9	m	3 3 4 3 3 3 2 1 3 2 1 2	3 3 1 1 2 2 1 1 1 1 2 1	46
8	9	1	D	C	9	m	3 4 3 3 5 4 2 1 1 1 1 1	2 3 2 0 2 2 2 0 0 0 2 1	42
									201
8	9	3	A	A	9	f	4 3 0 3 4 3 4 1 0 3 1 1	1 1 1 0 1 0 0 1 1 1 2 1	33
8	9	3	B	C	9	m	3 1 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0	1
8	9	3	C	A	9	m	4 4 3 4 1 0 3 4 0 5 2 4	3 1 1 3 2 2 2 3 0 1 0 2	50
8	9	3	D	C	9	m	3 3 2 1 3 4 3 2 0 0 0 1	0 0 0 0 0 1 0 0 0 1 0 0	21
									105
									306

(Experiment II)

Experimental condition					Subject data		Trials on discrimination task (Each trial consists of one two-choice response to each of eight stimuli)	Sum of errors	
(P)	(I)	(R)	Rep	Rei	GL	S		Trials 2-24	
8	3	1	A	C	9	f	2 4 3 2 2 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	12	
8	3	1	B	A	9	m	2 3 5 2 2 2 6 4 3 3 3 4 3 4 3 2 0 1 1 0 2 1 3 2	59	
8	3	1	C	C	9	m	6 3 3 4 1 5 4 2 3 1 3 3 1 1 2 0 2 1 1 1 1 2 3 2	49	
8	3	1	D	A	9	m	2 4 4 4 5 2 6 4 3 2 4 2 5 3 2 3 3 2 4 3 2 0 2 3	72	
									192
8	3	3	A	A	9	f	2 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	4	
8	3	3	B	C	9	f	5 5 3 1 3 3 2 2 2 0 2 1 3 1 1 1 1 1 3 3 0 0 1 1	40	
8	3	3	C	A	9	m	6 3 5 2 0 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0	14	
8	3	3	D	C	9	f	3 4 2 2 2 0 1 1 2 1 1 3 3 2 0 0 1 0 1 0 0 0 0 0	26	
									84
									276
									1,037

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